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The Internet of Things in the Financial Industry
Master's Thesis (20 ECTS)

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The Internet of Things in the Financial Industry

Abstract: The evolution of technology constantly gives rise to innovations that introduce innovative solutions and capabilities. Among these emerging technologies, the Internet of Things also brought attention. Numerous industries have explored and integrated IoT into their operational procedures. Nevertheless, the Financial Industry has been somewhat delayed in adopting these practical applications. This thesis delves into six research inquiries, collectively aimed at a central objective: comprehending how the financial sector can benefit from the IoT. To address this matter, data was collected from both a thorough review of the literature and expert interviews. The data underwent a process of refinement, analysis, and systematic organization within a conceptual framework. A noteworthy contribution of this thesis is the categorization of various use cases for IoT. The framework effectively clusters instances of IoT applications within the financial domain. Furthermore, it uncovers the capabilities and prerequisites of implementing IoT technology. Besides that, the framework also outlines the impact and value of each use case along with the challenges, timelines, and obstacles related to the widespread integration of this new technology.

Keywords: emerging technology, internet of things, IoT, financial industry

CERCS: P170 Computer science, numerical analysis, systems, control

Asjade Internet finantstööstuses

Kokkuvõte: Tehnoloogia arenguga kaasneb innovatsioon, mille tulemusena võetakse kasutusse uuenduslikke lahendusi ja tehnoloogiaid. Minu uurimusvaldkonnaks sai asjade internet. Paljud erinevad tööstused on arendanud ja integreerinud asjade interneti oma tööprotseduuri. Samas finantssektor on selles vallas vähem uuenduslik olnud.

See lõputöö põhineb kuuel põhilsel küsimusel, eesmärgiga mõista, kuidas finantssektor saab asjade interneti efektiivsemalt kasutada. Uurimuses on kasutatud kirjanduslikke allikaid ja intervjukeerimist. Materjali on analüüsitud ja täpsustatud vastavalt teema kontseptuaalsele raamistikule.

Lõputöö annab märkimisväärse panuse asjade interneti erinevate kasutsjuhtude kategoriseerimisse. Täpsustades asjade interneti rakenduste kasutamist finantsvaldkonnas. Lisaks toob see paremini välja IoT-tehnoloogia juurutamise eeldused ja võimalused. Raamistik kirjeldab seejuures iga kasutusjuhtumi mõju ja väärtust ning selle uue tehnoloogia laialdase integreerimisega seotud väljakutseid, ajakava kuid ka takistusi.

Võtmesõnad: arenev tehnoloogia, asjade internet, asjade internet, finantssektor

CERCS: P170 Arvutiteadus, arvanalüüs, süsteemid, kontroll

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1. Introduction

Technology has improved our lives and business from a variety of perspectives including increased automation, efficiency, productivity, and enabled new use cases[1]. As it is ever-evolving, technology continually gives rise to new technologies that bring forth innovative solutions and capabilities. These novel advancements are commonly referred to as emerging technologies. The emergence of novel technologies has been a subject of much debate in academic research and has become a central topic in socioeconomic discussions and initiatives[2]. The continuous and rapid progress of technology brought many changes and endless curiosity to explore more[3].

Emerging technologies are portrayed as those technologies that have the potential to gain social relevance within the next 10 to 15 years. This means that they are currently at an early stage of their development process[2], [4]. The verbal definition of “emerging” is also defined as “ the process of appearing”[5]. At the same time, they have already moved beyond the purely conceptual stage. Despite this, these emerging technologies are not yet clearly defined. Their exact forms, capabilities, constraints, and uses are still in flux[2].

Artificial intelligence (AI), the Internet of Things (IoT), Blockchain, Big data, Cybersecurity, Robotics, and Virtual Reality(VR) are currently the available new technologies[6]. Those novel technologies enable Human-Computer interaction and promise the exciting potential to create changes and progress in multiple markets and industries. Among these technologies, the Internet of Things(IoT) is familiar in our everyday life[7].

The term "Internet of Things" (IoT) refers to a network of physical objects, or "things," that have sensors, software, and other technologies built into them to connect to and exchange data with other systems and devices over the internet[8], [9]. These gadgets range from commonplace domestic items to advanced industrial machines[10].

In this thesis, IoT technology was defined as an interconnected network of devices capable of communicating with one another without requiring human intervention. This integrated system enables a seamless exchange of information and data, allowing for efficient and automated decision-making processes[11].

The development of IoTs enabled many opportunities for most Industries including Manufacturing, Automotive, Transportation and Logistics, Retail, Public Sector, and Healthcare[8]. For example in manufacturing, IoT contributes to the optimization of the production process by establishing wireless connections among types of equipment via the

Internet. This connectivity empowers manufacturers to remotely oversee and manage these assets, resulting in minimized downtime and increased operational efficiency[12]. However, its advancement and usage were not uniform across industries such as in Financial Industry[13]. The Financial industry is also a vast industry that recognizes the potential usage of IoT. However, how the financial industry will utilize the boon of IoT is still a controversial topic[14]. The reason is that the Financial industry is highly delicate because it deals with money transactions and possesses sensitive information. Thus, they are very susceptible to uncertainty, and severe privacy and security risks[15]. Here we are going to explore and bring to the surface the potential use case of IoT in the financial sector and how IoT can change traditional business processes.

This thesis aims to understand the prospective role of IoT devices in the Financial Industry. Most studies of the Internet of Things in the Financial Industry have been descriptive and didn't cover the impact and value of IoT technology in detail. However, in this thesis, the gap in the previous study will be uncovered and addressed. Additionally, the current state of IoT devices in the financial industry, and how IoT is perceived to change those processes via the interconnectivity will be analyzed in detail and with a more analytical approach.

In recognition of the rapidly evolving nature of technology, It has been also acknowledged that new use cases and possibilities continue to emerge in this field. As part of the research, it was tried to uncover and explore these emerging trends and potential applications. Moreover, the following research questions were formulated to address the aim of the thesis and come up with the possible classification of use cases of IoT technology in the financial industry based on that.

RQ1: What capabilities of IoT technology can enable the use cases in the Financial Industry?

RQ2. What are the potential use cases of IoT in the Financial industry?

RQ3: What are the prerequisites to backup IoT implementation?

RQ4. How IoT devices will impact Financial Industry?

RQ5. How could IoT bring value to financial products and services?

RQ6. What is the estimated time of IoT implementation and what challenges prolong the time?

To fulfill the objectives mentioned above, different stages were passed. Firstly, the review of relevant literature was conducted to investigate what has been done previously. The study aims and research questions were formulated to guide our investigation. As an effective method of qualitative data collection, semi-structured interviews were conducted. Finally, thematic analysis was used to identify the themes and patterns in the data to draw a result.

The contribution of this study is a framework that classifies potential use cases of IoT for the financial sector by considering the capabilities of IoT devices, prerequisites, potential impact, value proposition, and lastly challenges. As a result, the analyst in the Financial Industry who

seek the innovation of processes via IoT technology can access industry-related research work which can be beneficial to create awareness about IoT implementations.

Section 2 delves into the concept of the Internet of Things by providing a definition, an overview of its historical development, use cases across various industries, previous research work, and their contribution to this matter. Section 3 outlines the research methodology employed in our study. In Section 4, the results of the interviews were presented. Section 5 offers a discussion of interview results and literature review and the classification of use cases. In the final section, Section 6 summarizes the research conducted and presents the concluding remarks.

2. Background Information

This section covers an overview of IoT technology, its applications in both tangible objects and intangible processes, and an exploration of relevant literature on the subject.

2.1 The Internet of Things

IoT Technology refers to a set of physical things that are embedded with sensors and actuators and connect to computing systems across wired or wireless networks, which enables digital monitoring and even control of the real world. It has opened up a world of possibilities for businesses and consumers alike, from improved efficiency and productivity to enhanced convenience and automation[16].

This technology has been around for several decades, with the first known internet-connected device being a modified Coca-Cola machine at Carnegie Mellon University in 1982. This machine was able to report the stock of drinks and whether they were cold over the Internet[17]. However, The term "Internet of Things" was introduced later in 1999 by Kevin Ashton, managing director of the MIT Auto-Id Center[18]. Since then, the development of IoT technology has rapidly advanced, with more and more devices being connected to the internet every day[19].

Moreover, we should define the boundaries of what is an IoT device. The concept of IoT refers to a network of interconnected devices that can communicate with each other without the need for direct human interaction. These devices, often referred to as IoT devices, are designed to gather and share data, perform specific tasks, and provide various services, enhancing convenience and efficiency in our daily lives including smart switches, smart lights, cameras, and temperature/humidity sensors [11].

IoT technology has different applications across industries such as improved industry efficiency, healthcare cost reductions, better home convenience, and safer infrastructure. There may be countless other specialized uses for IoT that are bringing innovation, comfort, and ease to a whole new level in the world[20]. For example, Manufacturing as we know it is about to change thanks to the Internet of Things. Through improved security, reduced energy use, and real-time

data analysis for management, connected devices enable manufacturing floors to operate more effectively[21]. Tracking fleets or assets in the supply chain is one example use case of IoT in the Manufacturing Industry. It helps to watch over supply chain elements such as raw materials, containers, and finished goods to improve logistics, keep an eye on work-in-progress supplies, and report thefts and violations. As a result, manufacturers reduce issues associated with inefficient inventory management. Conducting manual inventory counts proved both time-consuming and susceptible to errors. In contrast, the utilization of tag scanning, which automates the transfer of data to the business management system, proves significantly more efficient, precise, and expeditious. Furthermore, the incorporation of asset tracking technologies plays a role in addressing theft throughout the entirety of the supply chain, starting from the manufacturing phase to the final stages of delivery[22].



Image 1: Tracking fleet or assets

Auditing the equipment performance is another example of an IoT use case in Manufacturing. These technologies contribute to greater predictability concerning asset breakage and downtime. The unpredictability of unexpected equipment failures, which can disrupt operations and incur substantial downtime costs, is mitigated. Through the deployment of intelligent tags equipped with sensors, operators gain the ability to oversee equipment health, receive alerts regarding potential instances of breakage, and proactively strategize maintenance endeavors. Monitoring the condition of production tools and field gadgets can help identify maintenance needs before they become expensive to fix or replace[22].

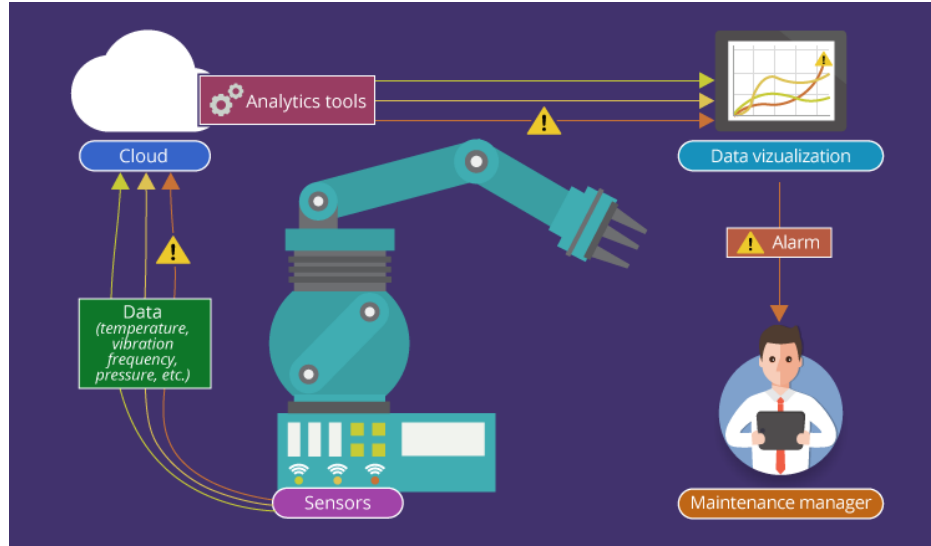


Image 2: Performance tracking of the equipment

IoT has received attention and study about processes involving physical objects like in Manufacturing. However, there is now growing interest in applying IoT in physical objects and processes involving non-tangible, such as those found in the financial industry and insurance sectors[23].

The insurance industry is an example of those that benefit from the usage of IoT devices by collecting the data to offer personalized insurance products and improve claims processing efficiency. For example, Allstate offers a program called Drivewise, which uses IoT devices to track drivers' behavior and offer personalized insurance rates based on their driving habits[24]. Drive wise enables access to information about how safe the driver drives the car, provides feedback about driving behavior, and based on the driving pattern insurance company offers personalized policy. Safe driving practices, such as observing safe stops, maintaining a safe driving speed, and limiting driving hours, can help to reduce the risk of accidents on the road. Insurance companies take these factors into account when assessing a driver's risk level and determining their insurance premiums.

Another industry involving non-tangible assets is the financial industry. Financial Industry refers to companies, organizations, banks, and institutions that assist the economy by offering financial services. It includes many sectors, such as banking and investing, consumer finance, mortgage, money markets, real estate, and retail[25]. In this industry, IoT has been explored and used for Automated teller machines (ATMs) and wearables. ATM is an early prototype of an IoT device that has been used in retail banking for decades. ATMs have been one of the IoT devices that have helped banks become much more efficient by enabling real-time transactions instead of having to wait in line to see a teller at a physical bank. These ATMs should also help banks cut

costs by decreasing the number of workers required in conventional branches, while also enhancing customer satisfaction[26].

Wearable devices can be brought as an example as well and they are increasingly being used in the financial industry to improve the customer experience, enhance security, and provide new services, for example, payment wearables. Wearable devices such as smartwatches or fitness trackers are being used to make payments at point-of-sale terminals. This technology allows for seamless and secure payments without the need for a physical card or cash[27]. As well as they can provide personalized banking. Wearable devices can also be used to provide personalized banking services and support to customers. For example, customers can use a smartwatch to check their account balances, transfer funds, or receive alerts about their account activity[27]. Wearable devices offer several advantages for the financial industry including convenience, security, and personalization. As IoT technology continues to evolve, we will likely see even more innovative applications of this technology in the financial sector.

Besides that, Visa made progress in the application of IoT by establishing a program, known as the Visa Ready Program for the Internet of Things[28], to enable IoT device manufacturers to integrate secure payments into their connected devices under Visa and EMVCo security standards and specifications, thereby allowing payments to be initiated from a variety of devices, such as watches and cars. Strategic partners of the Visa Ready program, such as Accenture, Coin, Fit Pay, Giesecke & Devrient, and Samsung, offer payment expertise and technical support for IoT innovators to enable payments, and they also apply for tokens through the Visa Token Service[29]. For Visa, promoting payments via the Internet of Things is a smart strategy for growth as it simplifies spending, which in turn can increase revenue and market share, and keeps pace with its largest competitor, MasterCard. To protect its customers from fraud, Visa has established the Visa Token service, particularly in light of businesses' concerns regarding the IoT hack that has limited consumers' ability to make widespread payments via wearable devices. Visa Token is a security feature developed by Visa that substitutes confidential account data on payment cards with a special digital identification code known as a token. This token allows for IoT payments to occur without exposing any sensitive information that could be hacked or compromised. To promote the extensive adoption of this new payment system, Visa created the Token Service Provider Program, which certifies third-party companies known as Token Service Providers (TSPs) to safely link token requests between merchants and card credentials to the token platform[28].

2.2 Related works

IoT devices have been successfully integrated into most industries and people's lives. Researchers from different sectors including the Financial industry have studied it.

In 2016, Vemula & Gangadharan offered an “Internet of Things” framework for data processing and performing analytics in the Financial industry[30]. They identified the lack of a unified framework for using IoT applications and analytics for banks and financial organizations. Thus their research focused on creating a conceptual framework based on IoT for the banking and Financial sector to help businesses understand and use the framework to develop applications in a way suitable for their prerequisites. They believed IoT will enhance customer experience and overall network infrastructure in banks only if big data and cloud accessibility are effectively integrated with IoT structure. This paperwork helped us to understand the different layers of IoT devices and how each layer communicates, gathers, and stores the data by filtering through each layer. The major contribution of the researchers is creating a framework that is highly reliable, multicast, dynamically expandable, and efficient with integrated analytics in place. However, they didn’t explore potential application areas and in this thesis, which will be contributed in this thesis by examining use cases in Financial Industry.

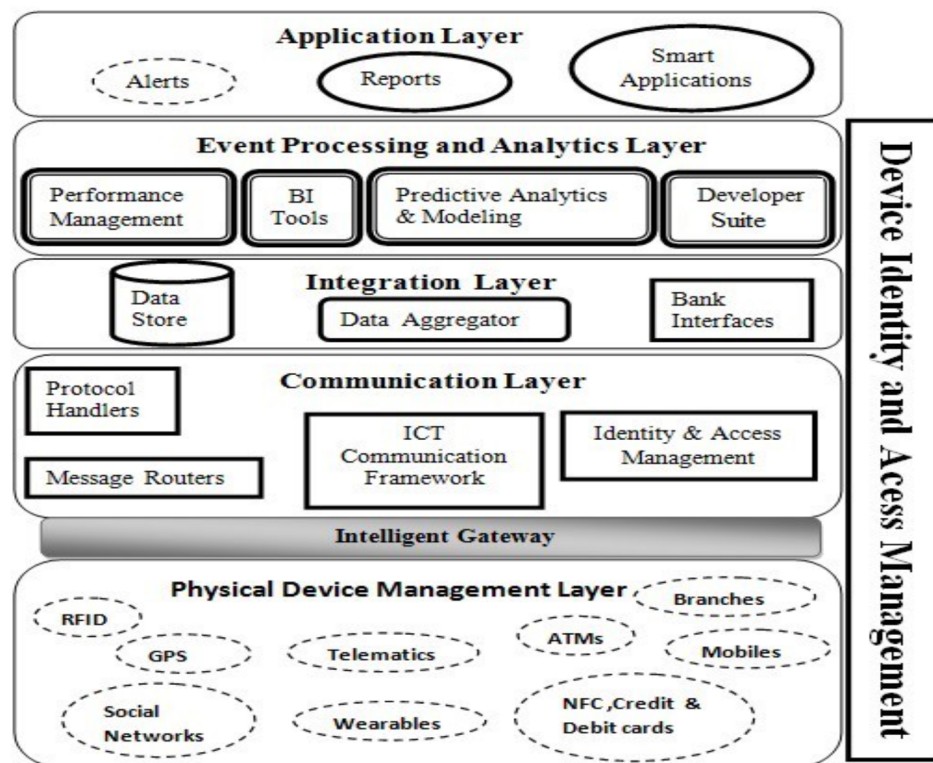


Figure 1: IoT Framework for Financial Industry

In 2019, Vijay Kumar studied the application of IoT in Finance and Banking[31]. He discussed issues and challenges in IoT implementation in banks along with the possible application areas to maintain profitability by preventing fraud cases. He mentioned Debt collection, Fraud prevention, Personalized offerings, and Capacity management as potential use cases. With the effective usage of data gathered through IoT devices, Banks and Financial institutions can

eliminate the cost of the debt collection process and prevent Fraud cases which are the major concerns of the banks. Besides that, the author described some changes in Product Planning & Management, Marketing, and Service fault. He also mentioned some issues and challenges in IoT implementation. Delivering Value to The Customer, Hardware Compatibility Issues, Data Connectivity Issues, Incorrect Data Capture Difficulties, Analytics Challenges, and Data Security issues are the ones discussed by the author. Additionally, he highlighted the importance of wearables in the financial industry. They have been a top target for banks worldwide due to their popularity and reach. The majority of watches currently on the market are phone-connected, however, numerous developments now make standalone wearables possible. As a result, wearable technology has become a hotspot for banking innovation. In addition to wearables, remote gadgets like Amazon Alexa are another area of interest for innovation banking. In conclusion, While the researcher did touch upon various use cases, changes, and concerns related to IoT, he did not cover how IoT will impact the Financial industry in detail. Additionally, how the use cases will bring value to the Financial industry was not covered which will be explained in this research work.

Later, G..Suseendran in 2020, investigated IoT applications under the title of “Banking and Fintech(Financial Technologies) Embraced with IoT Device”[32]. In this study, the challenges of Banking and FinTech especially potential Cyber security issues while connecting IoT devices was discussed. Additionally, the author briefly mentioned about use cases (Account Management on Things, Leasing Finance Automation, Smart Collaterals, Risk Mitigation In Trade Finance, Wallet of Things) which were reflected in Section 4. Although, the research covers some use cases, challenges of this technology was more prior topic.

Aznag & Tahanout introduced a research paper which is IoT solutions for Fintech and Banking industry[29]. The research covers some application areas of IoT devices in Fintech and Banking such as Payment using wearable devices as we already mentioned (section 2.1). The authors also mentioned 18 use cases and some of them were already covered in previous research work. Furthermore, a discussion on challenges was presented as well. Those use cases and issues were reflected in Section 4 in detail. Additionally, they talked about reasons that limit the use of wearable technology for contactless payments. Firstly, some people do not perceive any significant benefits of using wearable technology over traditional credit cards. Secondly, there is a lack of standardized points of sale for contactless payment technologies, which may require consumers to own multiple smartwatches for different stores.

Another research has been done by Abdelmaboud in 2022 who examined security and privacy issues and challenges to support the integration of blockchain technology with the Internet of Things[33]. Many IoT systems face issues with security and privacy due to cyber attacks. To address these issues, the researcher explored various aspects of blockchain technology such as distributed ledgers, smart contracts, decentralization, and security, and how they can be

integrated with IoT to mitigate security and privacy issues. The authors also discussed the prominent blockchain platforms like Hyperledger-Fabric and Ethereum that have been implemented for IoT applications. They highlighted the role of blockchain technology in expanding the scope of IoT applications and examined the latest developments in this area. However, this work introduced how IoT and Blockchain technology together can create a secure environment to boost the implementation of IoT technologies in general. When and how the emergence of technologies can bring changes in the Financial Industry has not been explained yet.

3. Methodology

Our goal is to understand the current situation of IoT and explore what are the use cases of this technology for the Financial Industry. It was also aimed to understand the capabilities of this technology, its prerequisites, and how the use cases will impact and bring value. After that, detect potential challenges and threats along with possible timeframe of adoption. And this section covers which methodology, approaches, and tools were employed to achieve our objective.

Starting with the main method, qualitative research was conducted because we believed it will help us to understand why, how, or what stands behind certain behaviors or thoughts[34]. This way comprehensive data can be gathered that leads to more informed analysis and better outcomes. The qualitative research method encompasses different practices[35]. Among the different qualitative data collection methods, semi-structured interviewing was the most suited to our purpose. This method allows both the interviewer and the interviewee to delve into the research topic in-depth while still maintaining a degree of structure and flexibility[36]. As a result, the main research questions can be answered and also got more valuable data that wasn't covered in the research questions. After defining the interview type, the next steps were followed: Preparation, Data collection, and Data Analysis.

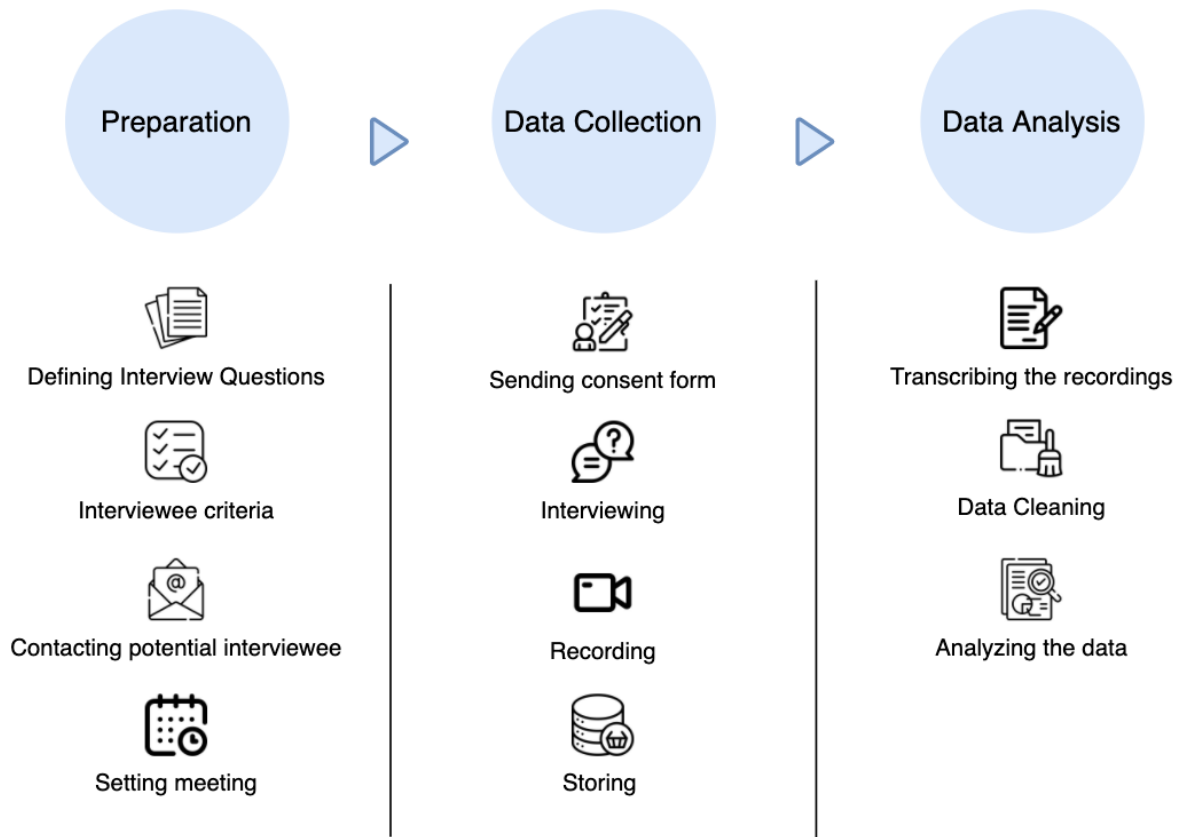


Figure 2: Research Stages

3.1 Preparation

The first phase of research was a critical step in ensuring the success and relevance of the study. This phase involved a literature review and proper preparation, which includes defining the scope of the research and the specific issues that need to be addressed. It helped to set the direction for the research process. After that, research questions were formulated to guide the collection of relevant data and ensure that the study's objectives are met.

3.1.2 Research Questions

After conducting a analysis and investigation, following research questions were formulated to address the identified research gap.

RQ1: What capabilities of IoT technology can enable the use cases in the Financial Industry?

Delving into the attributes of IoT that empower its application in the realm of finance. The previous research overlooked an examination of why industries are embracing IoT and the different aspects of this technology that could potentially drive use cases within the Financial Industry. Addressing these gaps is crucial for comprehending the full spectrum of IoT's capabilities and the potential outcomes it can bring forth.

RQ2: What are the potential use cases of the Internet of Things in the financial industry? delve into potential use cases. Although previous literature reviews have already mentioned the various use cases of IoT, new use cases may appear and our research goal is to uncover them and contribute to the understanding of IoT applications.

RQ3: What are the prerequisites to backup IoT implementation? To investigate the necessary elements for effectively applying IoT within the Financial Industry. It is interesting to understand how both the external and internal environments contribute to facilitating this introduction. Prerequisites were not discussed in previous literature and we aim to understand them in this thesis.

RQ4 :How IoT devices will impact Financial Industry? This research question aims to explore the impact of different usage scenarios on both client interactions with financial services and the operations of financial institutions. The literature review showed us the impact of IoT on clients and financial institutions has not been investigated in detail. This investigation will contribute to the knowledge base by exploring the implications for client experiences, service delivery, operational processes, and overall industry practices.

RQ5: How could IoT bring value to financial products and services? to determine the value of the potential use cases in the Financial Industry. Previous literature reviews had an optimistic approach to the implementation of IoT in the Financial Industry. It was believed that IoT can be a game-changing technology for the Financial Industry however the value of the use cases has not been covered in detail. Thus, with this research question, we aim to investigate the magnitude of the benefit of implementing IoT technology and understand the more realistic role of IoT in the Financial Industry.

RQ6: What are the barriers that prevent the implementation of IoT applications in the financial sector? Finally, another research objective is to comprehend the challenges associated with adopting IoT in the Financial Industry and identify potential threats it may introduce. While previous literature reviews have touched upon various challenges and threats, it is crucial to acknowledge that certain issues might have been resolved or overlooked. Hence, this research question aims to deepen our understanding of the barriers that hinder the successful implementation of IoT technology. By exploring these challenges, we can contribute to a more

comprehensive understanding of the current landscape and provide insights to mitigate potential obstacles in the adoption of IoT in the Financial Industry.

3.1.3 Interview Questions and Preparation

Research questions served as a guide for formulating the interview questions to delve into the research areas and gather the relevant data. By using the research questions as the main domain, we derived various sub-questions deeper into specific aspects of the research. For example, “*In what ways can the IoT transform financial services and organizational processes?*” was derived from RQ4 to understand the impact of IoT on financial institutions. The interview questions were designed in a structured manner, comprising three parts: introductory questions, exploratory questions, and optional questions (see Appendix I). This approach ensured a consistent and comprehensive coverage of the relevant topics and facilitated a productive and insightful interview process. The introductory question served multiple purposes during the interview process. Firstly, it acted as warm-up questions, allowing the interviewee to ease into the conversation and feel more comfortable sharing their insights. Additionally, the question played a crucial role in gaining a better understanding of the interviewee's expertise, professional background, and relation to the topic. The exploratory questions derived from Research Questions 1, 2, 3, and 4 served as the primary source of data during the interview process. These questions were designed to delve deep into the specific areas of inquiry outlined in the research questions. By asking these exploratory questions, it was aimed to gather rich and detailed information directly related to our research objectives. They provided a focused and targeted approach to gathering in-depth information, ensuring that the interview data was directly relevant to our research objectives and contributed to a comprehensive understanding of the topic. Finally, the interview questions were concluded by including optional ones to gather insights from different perspectives and specifically explore the use cases mentioned in the literature review. The optional questions served as a valuable addition to the interview questions, enabling us to gather diverse perspectives and explore the mentioned use cases in detail. These questions provided an opportunity to explore specific aspects of the research topic that may not have been covered by the primary research questions.

3.1.4 Interviewee Search

Once the appropriate questions were designed, potential interviewees were searched. To ensure the selection of knowledgeable participants, certain criteria were defined to help validate interviewees.

The expertise area was one criterion when identifying potential participants for the research. As the research topic encompasses two domains, namely IoT and the Financial Industry, we focused on individuals with expertise in these specific fields. To ensure the selection of knowledgeable participants, we tried to identify experts who have demonstrated expertise and a background in both IoT and the Financial Industry.

The experience was another factor to consider. We sought individuals with industry experience, particularly in the areas of IoT and the Financial Industry, to ensure that research incorporated insights from those who have directly engaged with the practical aspects and challenges within these domains.

Selecting participants with diverse backgrounds helped to mitigate potential biases and ensure that research outcomes reflected a representation of the broader industry. This approach allowed us to identify patterns, similarities, and differences in opinions, practices, and challenges across different segments of the IoT and Financial Industry landscape.

The interviewee search process started with defining the relevant keywords. Different combinations of “IoT”, “Financial Industry”, “Financial services”, “Innovation”, “R&D”, “Banks”, “Fintech” and ect were used to find a relevant expert. These keywords were selected to ensure a targeted approach in finding experts who possess knowledge and experience in the intersection of IoT and the Financial Industry. The selection of keywords was an iterative process, involving refinement and adjustments as the search was conducted. Keywords were continuously evaluated and modified to ensure that the search yielded relevant and qualified experts for interviews.

Then different platforms were tested to reach out to the prospective interviewees. First, we utilized YouTube as a resource to find relevant speakers at conferences or events related to the research topic. By watching videos and presentations on YouTube, potential individuals were discovered who have shared their knowledge and insights in the field of interest. Once we identified potential experts through YouTube, we proceeded to extract their contact details, such as email addresses, to establish communication. Another channel was Twitter, by entering relevant keywords related to the research topic, we searched for individuals or organizations that actively engage in discussions or share insights on Twitter. However, these two sources did not give results. Thus, we moved to LinkedIn to iterate the same processes. Among the available platforms, LinkedIn was the effective source to reach out to the potential interviewee.

Once the participant expressed interest in being part of the study, the interviewee was explained and introduced to the consent form. After the mutual agreement, interview dates and online platforms such as Google Meats and Microsoft Teams were used based on the interviewees’ preferences.

3.2.1 Interviewees

Next, we interviewed the domain experts. 5 interviews were conducted online and 3 answers were provided in a written format due to participants’ busy schedules. All participants have diverse backgrounds and years of experience, which was reflected in the table below. To maintain the confidentiality of the participants we used coding as “IP-X” which stands for “IP” as “Interview Participant” and “X” as “order of the interviews”.

Interview participants

| ID | Domain | Occupation | Year of Experience |
|-------------|---------------------------|---|---------------------------|
| IP-1 | IoT | Researcher | 2 years |
| IP-2 | Financial Industry | Manager | 7 years |
| IP-3 | IoT | Top level manager at IoT company | 22 years |
| IP-4 | IoT | Co-founder at IoT company | 8 years |
| IP-5 | IoT | Manager | 2 years |
| IP-6 | IoT | Founder at Iot Company | 8 years |
| IP-7 | Financial Industry | Consultant | 4 years |
| IP-8 | Financial Industry | Business developer | 3 years |

3.2 Data Collection

The data collection process involved gathering two types of data. Firstly, we conducted a literature review where we analyzed various aspects such as potential use cases, discussion points, limitations, and implications of IoT. We relied on academic articles, reports from reputable research companies, and white papers published by industry experts for the literature review. Then based on the gap in the previous literature review, we conducted semi-structured interviews.

3.2.2 Interview

Interviews were started with small chats to make the atmosphere more friendly and relaxed, encouraging them to freely express their thoughts and insights. The process continued with the introduction of the researcher and an explanation of the study.

Then before starting the Interview questions, interviewees were asked to confirm the recording of the meeting. Obtaining confirmation for recording ensured that the information shared during the interview would be accurately captured and analyzed in subsequent stages of the research. To facilitate recordings, the QuickTime Player application was used.

The interview process started with the introductory questions. The participants were first asked to introduce themselves, provide information about their background, and explain their relation to the topic.

Then we continued with the RQ1, RQ2, RQ3, and RQ4-related questions and optional questions. The interviews were semi-structured and during interviews, follow-up questions were asked to clarify the interviewees' input and also gather more detailed data. The interviewees were asked to express their thoughts within approximately 30-45 minutes of the call. The shortest meeting lasted 23 minutes and the longest one 50 minutes. The collected consent forms and video recordings were saved for data analysis.

Overall 8 answers were collected. 5 of them were connected via online meeting and 3 of them were provided in written format. The shortest written answer was 1 and the longest was 2 pages.

3.3 Data analysis

The final stage of this section involved data analysis, which was crucial for identifying patterns, trends, and key insights from the collected data. The analysis process allowed us to investigate the responses and extract meaningful information that could contribute to the overall understanding of the research topic.

3.3.1 Thematic analysis

Thematic analysis is an approach utilized for examining qualitative data, typically found in texts like interviews or transcripts. Virginia Braun and Victoria Clarke originally developed this procedure for psychology research, however, it can be applied to other research subjects[37]. We also employed this method as the main approach to interpreting the collected data. This qualitative research method involves identifying themes and patterns within the data and analyzing them to develop a deeper understanding of the research question or topic[37]. The first step was familiarization which is important to get acquainted with all the data that was collected before starting to analyze. It involved converting the interview recordings into a readable format. To accomplish this, we used Airgram.com, a transcription service that accurately transcribes audio recordings into written text. In total, 200 minutes of recording were transcribed and the transcriptions were then compiled into a single document to facilitate further analysis. The transcribed answers were 41 pages in length. Once the transcriptions were obtained, the data was structured to identify and organize the interviewee's responses. This involved going through the transcriptions, removing unnecessary parts, segmenting the text into meaningful units, and categorizing them based on the interview questions. Next, a deductive approach was used, which involved approaching the data analysis with predetermined themes or expectations that were expected to be reflected in the outcomes of the interviews[37]. This approach ensured that the analysis focused on specific areas of interest and aligned with the research questions. Thus, we first derived themes from research questions such as "*Current state*

of IoT”, “Use cases”, “Value”, and “Challenge”. The derived themes provided a framework for organizing and categorizing the interview data, enabling a systematic examination of participants' responses within the predetermined areas of investigation.

After defining the initial themes, we moved to the coding of the data which means emphasizing the sections of responses with phrases or sentences that describe the content. This is the initial step of actually starting the analysis of the data. Coding was done manually which means it relies on personal judgment.

The input provided by each participant was carefully analyzed and coded. These codes helped to summarize the main points, providing an overview of the common meanings that emerged. Simultaneously the answers were transformed to the Miro board.

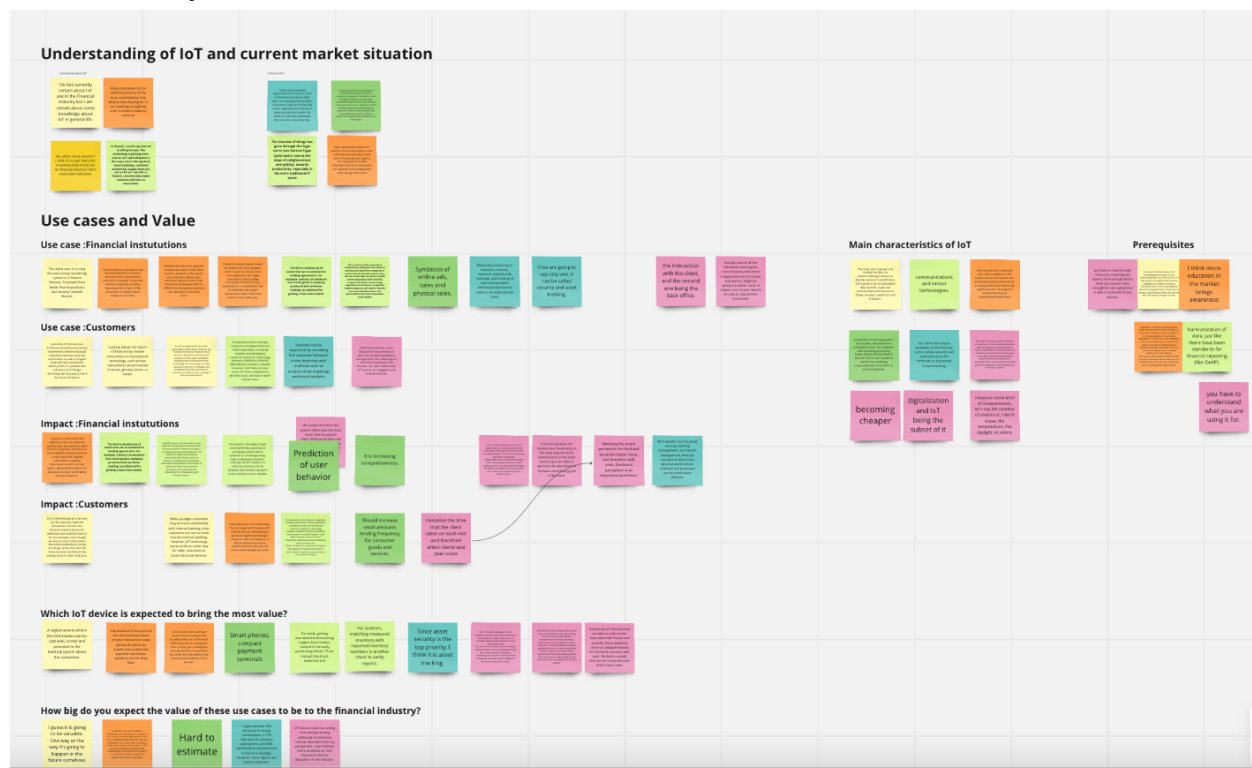


Image 3: Analysis in Miro board

After defining initial themes and codes, went through the data again to define the final themes. This involved revisiting the interview responses and critically analyzing them to ensure that the final themes accurately captured the key ideas and patterns present in the data.

| Themes | Sub-themes | Codes |
|--------------------------------|------------------------|---|
| Overview | Understanding of IoT | Uncertainty, Positive expectations, differences in Perception, Passing the hype curve, IoT is not a disruptor, Limited exposure, PoS terminals, Different level of adoption, Expansion of payment methods |
| | Current use case | |
| Use case | Financial institutions | Tracking, Fraud prevention , Security checks, Automatic payment, Capacity management, Customer Analysis, Micro payment, No use case, Collateral, Automated reporting, Sales, Monitoring, Building and brach management, Customer service, Back-office improvements, Limied usage for customer |
| | Customer | |
| Characteristics | | Data reading, Speed, Communication, Cheap, Contactless, security |
| Prerequisites | | Secure environment, Infrastructure, Strong connectivity,5G expansion, Secure integration, Knowledgable experts, Market readiness, Demand, Education, Regulation, Standardization, Smartphone support, Changes based on need, Financial capital, Supply of devices, Training with sufficient data, Data validation |
| Impact | | Better customer experience, Digitalization, Better access to the service, Easy transactions, Bad customer experience, Support CRM department, Getting automated reports, Data collection, Increased competitiveness, Increase in lending frequency, Credit score increase, Uncertain |
| Value | | Smooth transaction, Better customer experience, No value, Automation, Security track, Asset tracking, Cost reduction, Better customer experience, Better bank image, Generate more revenue |
| Challenge | | Privacy issues, Security, Regulation, Age gap, Data accuracy, Managers' interest, Lack of interest, Lack of trust, Unrealistic expectation, No issue, Lack of standardization, Low Rol, Lack of experts, Lack of understanding of trends |
| Time frame | | Couple of years, Changes based on adoption level of IoT in countries , Gradual adoption, Ideas in 15 years, Implementation in 2 decades ,10 years, 5 years |
| IoT device to bring most value | | Cameras, Robots, POS, Smartphones, Compact payment terminals, Asset tracking technology |

Figure 3: Codes derived from interviews

3.4 Refinement Tools

To enhance the readability and address grammar issues in the thesis, we employed two valuable tools: Chat GPT and Grammarly. Chat GPT, an AI-based language model, was utilized to generate more coherent and structured sentences, improve the overall flow of ideas, and enhance the clarity of the content. It provided helpful suggestions and alternative phrasing options to refine the writing.

In addition to Chat GPT, we also relied on Grammarly, a widely-used writing assistant software. Grammarly helped to identify and correct grammar, spelling, punctuation, and other language-related errors in the thesis. It provided valuable insights and recommendations to ensure the correctness and accuracy of the written text. By carefully reviewing and incorporating

the suggestions provided by Grammarly, we were able to polish the thesis and enhance its overall quality.

4 Result

This section provides an overview of the findings obtained from the literature review and interviews conducted. Section 4.1 focuses on addressing Research Question 1 (RQ1): *What capabilities of IoT technology can enable the use cases in the Financial Industry?*

Moving forward, section 4.2 delves into RQ2: *"What are the potential use cases of the Internet of Things in the financial industry?"* In this section, we first examine the potential use cases associated with IoT in Financial Industry. Then it will be followed by section 4.3 which reflects results for RQ3: *What are the prerequisites to backup IoT implementation?* Here, necessary elements to support the successful integration of IoT will be discussed.

Next, section 4.4 dives into addressing RQ4: *"How IoT devices will impact Financial Industry?"* This section aims to demonstrate the changes foreseen by the interviewees in the industry as a result of IoT implementation.

Section 4.5 presents findings for RQ5: *"How could IoT bring value to financial products and services?"* Here, we outline how IoT can enhance the value proposition of financial offerings, as well as the feasibility of the use cases.

Lastly, RQ6: *"What are the barriers that prevent the implementation of IoT applications in the financial sector?"* is explained in the 4.6 section, highlighting the challenges and obstacles that hinder the widespread implementation of IoT applications in the financial sector. Besides that, we asked about the expected timeframe to overcome the obstacles.

4.1 Capabilities of IoT

To explore the potential of IoT use cases, we posed a question to the interviewees regarding the primary characteristics of IoT that facilitate these possibilities. As a result, the interviewee highlighted both common and distinct thoughts of characteristics of IoT technologies such as data acquisition through sensors, rapid processing speed, effective communication, tracking, security, data sharing, cost of technology, and digitalization.

1. Data acquisition is one of the primary characteristics of IoT technology which is enabled by embedded sensors which means the technology can evaluate the external and internal environment and store the data. This characteristic was mentioned by IP-1, IP-4, and IP-7. Specifically, IP-1 explained, *"The major part is going to be reading the data via sensors. Utilizing a camera to identify a person's identification, that's going to be actually digital data by itself, is just one instance where the Internet of Things can play a significant role in finance"*

2. Another feature was processing speed meaning how much information can be received at a time, and how quickly that information can be processed which enables quick adaptation to the changing environment and facilitates responsive actions based on the processed data. IP-5 mentioned *“Capabilities of tracking people's actual place, data speed, and the possibility to react. 5G combined with increasing processing power allows ultra-low latency and can react to your moves in real life very quickly by responding with some offers in your smartphone”*.
3. The communication and data-sharing feature of these technologies is enabled by the connectivity of IoT devices through a wireless internet connection. This feature facilitates the transmission of data, receives commands, and performs actions based on that data. This characteristic was mentioned by IP-4, IP-7, and IP-8 during the interview. More specifically IP7 said *“the speed of communication. With the introduction of communication between different devices is becoming much faster. Therefore the performance of the devices plus also the central server that's able to perform all the measurements or calculations is becoming faster. Therefore the banks and the management staff are getting the information faster”*.
4. Tracking was another mentioned characteristic which means sensors and connected devices can remotely monitor and manage an asset's geo position and movements. Based on the interview output, tracking can help to maintain the security of financial assets. IP6 mentioned that *“IoT solves the unique problems of the financial sector, where security and certainty are at the forefront, as it provides instant tracking”*. However, IP-5 and IP-7 talked about the additional advantages of tracking, *“Measuring let's say the number of visitors”*
5. The low cost of materials seemed an additional positive aspect of IoT technology meaning that those devices are getting cheaper to produce. This can bring IoT into the mainstream and lower the cost of investment. IP-7 said that *“the devices were becoming cheaper and cheaper. So, this means each device costs less than ten cents, depending on the device, and therefore they are becoming more accessible, especially for companies that do not specialize in the technology sector”*. And also explained that *“I think for most of the companies trying to introduce IoT devices, the amount of investment is a crucial factor.”*
6. The no-contact feature was brought up as well which means these technologies eliminate the need for physical contact to carry out financial activities. Based on IP-2's answer *“IoT can help do the less physical ways of the credit card and the debit card and all these things”*.
7. Lastly, being a part of digitalization also support the adoption of IoT technology. IP-7 mentioned that *“Digitalization and IoT being the subset of it, is the primary case. Well, at least maybe in some countries, when there is a global trend and then some management is trying to get on top of that global trend and introduce all these new trends into their*

companies, and that might be also the factor, although sometimes the trend might not have use cases in the company.”

| # | Charecterstics | Description | Mentioned |
|---|---|--|------------------|
| 1 | Data acquisition | By continuously monitoring various parameters such as temperature, humidity, motion, and more, IoT devices can capture valuable information about their surroundings. | IP-1, IP-4, IP-7 |
| 2 | High Processing speed | This attribute allows IoT systems to swiftly adapt to dynamic environments and take responsive actions based on the processed data. The processing speed plays a crucial role in enabling real-time decision-making and ensuring timely responses to the ever-changing conditions and demands of the IoT ecosystem. | IP-5 |
| | Tracking | With tracking functionality, IoT technology enables organizations to have real-time visibility and control over their assets. Through the use of sensors, assets can be monitored and tracked throughout their journeys or within designated locations. | IP-5, IP-6, IP-7 |
| 3 | Communication, and data-sharing feature | IoT devices can exchange data, transmit information, and interact with other devices or systems within the IoT ecosystem. This connectivity enables the efficient sharing of data, enabling real-time monitoring, control, and analysis of connected devices. | IP-4, IP-7, IP-8 |
| 4 | The low cost of materials | The affordability of IoT devices promote their integration into everyday objects, creating a connected ecosystem that enhances convenience, efficiency, and productivity. With the declining cost of materials, IoT technology becomes more accessible to businesses and consumers, fostering innovation and driving further advancements in the field. | IP-7 |
| 5 | Contactless | Ability of these technologies to eliminate the requirement for physical contact when conducting financial activities. This feature has gained significance, particularly in recent times when minimizing physical contact has become crucial for health and safety reasons. | IP-2 |
| 6 | Digitalization | By integrating IoT into existing digital infrastructures, businesses can establish seamless connectivity and data exchange, enabling them to fully leverage the benefits of digital technologies. In this way, IoT becomes an integral part of the overall digital transformation strategy, driving the adoption and utilization of IoT technology within various sectors. | IP-7 |

4.2 The use cases of IoT

In this section, we presented findings and a literature review for RQ2: *"What are the potential use cases of the Internet of Things in the financial industry?"*. Interviewees were prompted to consider potential use cases. In addition to interview outcomes, potential use cases were found in the literature review analysis.

Upon analyzing the findings, it becomes apparent that there are varying perspectives. The interview finding relieved that one of the main use cases for the Financial Industry is security and fraud checks (IP-1, and IP-3) which can be powered by tracking, communication, and data-sharing feature of IoT technology. Financial institutions handle sensitive and confidential data, such as customer financial information and transaction details, making them prime targets for fraudulent activities. By introducing IoT technologies, financial organizations can strengthen their security measures and minimize the risk of fraud through customer identification, behavioral analysis, and real-time monitoring. Money laundering can be one of these fraud activities and IP-1 stated about preventing money laundering to maintain security, *"The initial start is to stop the anti-money laundering system in the finance industry. So people have better financial products and security towards finance"*. And similarly, IP-3 said *"I think real-time mechanisms will be very important to conduct security checks, fraud checks that there is liquidity. I think that real-time capability would be very important as part of the processes to conduct these measures of checks"*. Additionally IP-1 mentioned *"Currently, KYC (Know Your Customer) procedures are being implemented where individuals verify their identities, and this information is used to mitigate financial risks and prevent identity theft. It's possible that IoT (Internet of Things) technology will also play a role in the future of finance"*.

The outcome from the literature also supports the interviewees' thoughts. Sadanand Vijay Kumar mentioned that, although the IoT system can detect fraud by monitoring accounts and analyzing sensor data from applications, it also presents an opportunity for fraudsters to exploit device vulnerabilities and insecurity. This can lead to identity theft, customer data theft, and privacy violations[31]. To address these issues installing IoT-enabled security systems at points of usage, such as ATMs, can help prevent debit/credit card fraud. Citigroup is currently testing ATMs that use eye-scanning technology to validate transactions. Besides that Aznag & Tahanout also discussed about Know your customer[29]. To combat fraudulent activities and money laundering, banks have implemented a program called "know your customer" which verifies customer details. The integration of IoT with digital identity verification will enable financial institutions to analyze and modify the financial behavior of customers, allowing them to offer tailored services and products. Another piece of literature also discussed similar applications as Account Management on Things. Using biometrics such as voice or touch can simplify accessing accounts through digital channels from anywhere.

During the interview, the interviewee mentioned an additional use case for the discussed technology, which is backed-up tracking capability which was reflected in section 4.1. We delved further into the topic and uncovered various usage cases associated with tracking, including security maintenance, customer analysis, capacity management, scoring, and loan assessment.

1. To enhance security measures, tracking can be employed in various ways, such as asset tracking, branch monitoring, and customer tracking. These applications can significantly contribute to maintaining a secure environment. IP-6 mainly discussed security and asset tracking together, *“If we are going to say only one, it can be called security and asset tracking”*. Moreover, specified that *“Electricity monitoring of branches, security, customer analysis with heatmap, and tracking of cash transportation vehicles and personnel seem to be expected use cases”*. IP-7 more specifically mentioned that the security of financial assets can be also maintained, *“Actually control all the individuals entering the room because, well, there is always the risk of fraud. One person might be taking out plastic cards or maybe cash. So you have to be able to control their movement. You have to also be able to control their communications with the outside world outside of this room”* or potentially *“If I give my corporate card to another person, that person can enter the room and then take all the internal information and sell it to the other company. The movement trackers, the computer vision that's based on how you move and then identifies if it's you or the other person may be using your map.”*
2. Capacity Management: By analyzing the load of each person and branch, businesses can gain insights into resource utilization and distribute the workload more effectively. By tracking the activities and performance of individuals and branches, organizations can identify areas of high demand or underutilization. This information enables them to allocate resources more efficiently, balance workloads, and make informed decisions regarding capacity planning. IP-7 mentioned *“By introducing those IoT devices plus measuring on the heat map the most visited places in the bank branch, you can optimize the operations of the bank client-facing part of the bank”*. Additionally *“What employee is the most loaded due to the heavy traffic of the consumers”*.

Sadanand Vijay Kumar also mentioned Capacity Management in their research work[31]. IoT-enabled monitoring can be used to measure average wait times, identify ideal staffing and counter configurations, and determine the geographic distribution of clients. This data can inform decisions about opening new branches and maximizing the quantity and location of cash dispensers and effective capacity management.

In another research, Aznag & Tahanout discussed a similar use case which is Smart Branch[29]. Transforming a traditional retail bank branch into a smart branch through the use of video analytics and sensors can enhance the retail banking experience and monitor potential threats.

3. Loan Automation: IoT technology can play a pivotal role in automating different stages of the loan process. By integrating IoT devices and sensors, financial institutions can gather real-time data on applicants' financial behavior, creditworthiness, and collateral.

This data can be automatically analyzed, processed, and fed into loan management systems, significantly reducing manual efforts and paperwork. IP-4 pointed out *“Monitoring of assets that act as collateral in lending agreements. For example, sensors can measure how much goods a company produced and use those readings as collateral for getting a loan from a bank.”* IP-8 mentioned that *“To forecast the next steps of our potential customers and to be ahead of their even data actions in scoring. That is the exact size that we are using for IoT helps us here within the data that we insert on need and within some logic algorithms that we have already coded. We by IoT to forecast the consumer potential risks or the reports toward our product. It's usually because the scoring is used in the market for credit terms, so it helps the under bank population have a chance to get credit”*. Additionally IP-7 explained *“By introducing those, the companies being more advanced, more technologically advanced, more efficient, therefore they are generating good financial results. They can they are able to improve their credit scores in the bank, therefore improving their success rate to get the loan”*. In the literature, Suseendran G talked about Smart Collaterals and explained the use of IoT devices can give financial institutions better control over client assets used as collateral, such as monitoring their condition, whether it be cars or homes[32]. Short-term financial offerings like machinery, cars, and building home loans can be provided digitally and automatically.

4. Automated reporting, the ability of IoT technology to collect real-time data, analyze it, and generate automated reports offers businesses valuable insights, improved decision-making capabilities, and operational efficiency. IP-4 mentioned *“The audit reporting of sustainability (ESG) goals: like auditors use financial data from companies to produce financial audit reports, they can use sensor data to report to which extent companies meet their ESG targets. This will be of increasing importance in the future, as publicly traded companies will need to become more sustainability aware and shareholders will need independent audit reports”*.
5. Payments innovation, revolutionizing the way transactions are conducted and enhancing the overall payment experience. IoT-enabled devices and systems can streamline payment processes, improve security, and enable innovative payment methods. IP-1 mentioned that *“Maybe the next biggest thing might be how the transactions happening at the stores, grocery stores or even in banking”*. In addition, IP-3 also talked about potential changes in payment *“I do believe the point of the sales terminal where remote transactions make personnel able to be mobile and conduct the payment transaction anywhere on the shop floor. For example, in some cases even we have seen it's more concept than broadly rolled out in the world where you can as a consumer enter a shop, pick the goods that you want, and leave the shop without any personnel intervention in the process”*.

The interviewee also described use cases of smart accessories in micropayments . The integration of IoT technology into smart accessories and the facilitation of micropayments offer novel and

convenient ways for consumers to make transactions. Moreover, IP-3 mentioned the importance of micropayment by stating *“I believe that the micropayment is important where credit cards become obsolete or the typical actors like Visa, Mastercard, American Express, Diners Club have been challenged with the different micropayment services that take place from other actors”* and explained his view about IoT in micropayments *“I think the market demonstrates an adoption of smart gadgets that it's open to conduct new micropayments. For larger transactions, what a large transaction is I think it's very individual on a country basis, but for relatively seen larger transactions I don't think that smart gadget is a viable way”*.

We also found out that, previous researchers also mentioned Wallet of Things[29]. As more devices become digital and smart, every device can be connected to a wallet, and all banks can use automated payments through IoT. For example, maintenance services can be stopped automatically using the wallet. Besides that, Connected car payment, By using secure vehicle connectivity and technologies such as geolocation and voice-activated controls, a connected car can serve as a payment agent for various goods and services, such as ordering spare parts, fuel/charging stations, parking, gas, shopping, toll collection, and food and beverage at car restaurants[29]. Payment options can be card-on-file or remote, and secure payment tokens can be exchanged between the car and the merchant through means such as NFC, Bluetooth Low Energy, or QR codes. These activities are part of the Alliance's efforts to develop connected car payment systems. In 2016, Mastercard partnered with General Motors (GM) to create the OnStar Go platform, a cognitive mobility platform that allows drivers to make payments for various transactions. With the advancement of the Internet of Things, connected cars will play a significant role in the payments industry, offering various opportunities for drivers and passengers. This will require collaboration between car manufacturers and financial technology companies, as well as financial institutions like banks.

Additionally, smart home assistants provide opportunities for payment, such as the integration of Capital One with Amazon's Alexa to allow customers to pay their bills, and UK's Starling Bank allowing customers to use Google Home to make payments and balance inquiries through voice commands [29].

Lastly, IP-5 saw *“Symbiosis of online ads, sales, and physical sales”* as prospective use cases of IoT meaning that IoT can simplify the reach to the customers. This convergence of IoT technology with advertising and sales strategies opens up new avenues for businesses to connect with customers in a more seamless and targeted manner.

There have been some use cases that were not mentioned by Interviewee which are listed below. Leasing Finance Automation: The emergence of new leasing models has enabled digital assets to be utilized globally, transforming traditional products and services. For example, the bank can remotely lock or disable leased resources as needed[32].

Risk Mitigation in Trade Finance: Radio Frequency Identification(RFID) is used to estimate the high value of products in the monetary space. IoT can help monitor the transportation of

sensitive goods, such as medical items, resulting in better-informed decisions and risk mitigation in trade finance[32].

Besides defining the potential adoption of IoT technology in the Financial Industry, we found out some participants expressed skepticism in their statements such as IP-1 saying *“I am not currently certain about IoT use in the Financial Industry but I am certain about some knowledge about IoT in general life.”* Similarly IP-2 *“thinks it's a topic that is mostly for manufacturing but for the Financial Industry I don't know how it will work”*. IP-4 also mentioned *“In fintech, I would say that IoT is still quite new. The technology is getting there, and we see rapid adoption in the easy sectors like agritech, smart buildings, condition monitoring, supply chain, etc, but as far as I can tell, in fintech, commercially viable solutions still have to materialize.”*

On the other hand IP-3 expressed previous failure of implementing IoT by the companies *“Many companies do not fulfill the promise of the level of profitability that they've been hoping for or not reaching enough big scale to make it viable to continue.”*

Moreover, IP-2 expressed *“IoT can help in again the same thing being contactless. Otherwise, in the financial sector, IoT is it's not that helpful”*. He also explained that *“What we are doing as a bank is doing financial anti-money laundering use cases which has no application of IoT. It is more about looking into your transactions. So if you are transferring money from, let's say Syria to the Netherlands and buying something in Iran with those funds that's all digital. It has nothing to do with IoT”*.

IP-7 argued that *“With the IoT devices much because the only interaction point for me with my banks is through either the mobile app or the Internet banking in my browser. So. I don't believe that IoT devices are engaged much in those activities.”*

| Use Case | Description | Mentioned |
|-----------------------|---|-----------------|
| Anti-money laundering | Financial organizations can strengthen their security measures and minimize the risk of fraud and anti-money laundering by customer identification, behavioral analysis, and real-time monitoring | IP-1, IP-3,[31] |
| Know your customer | Financial organizations can verify customer details. The integration of IoT with digital identity verification will enable financial institutions to analyze and modify the financial behavior of customers, allowing them to offer tailored services and products. | IP-1, [29] |
| Security measures | Financial organizations can maintain a secure environment by tracking in various ways, such as asset tracking, branch monitoring, and customer tracking. | IP-6, IP-7 |

| | | |
|--------------------------------------|---|------------------------|
| Capacity management | Financial organizations can track the activities and performance of individuals and branches, and organizations can identify areas of high demand or underutilization. | IP-7, [31], [29] |
| Loan automation | Financial institutions can gather real-time data on applicants' financial behavior, creditworthiness, and collateral. This data can be automatically analyzed, processed, and fed into loan management systems. | IP-4, IP-8, IP-7, [32] |
| Automated reporting | Financial institutions can collect real-time data, analyze it, and generate automated reports offers businesses valuable insights, improved decision-making capabilities, and operational efficiency | IP-4 |
| Payment automation | Financial institutions can revolutionize the way transactions are conducted and enhance the overall payment experience including how the transactions happening at the stores, grocery stores or even in banking.As well as, the point of the sales terminal where remote transactions make personnel able to be mobile and conduct the payment transaction anywhere. | IP-1, IP-3 |
| Smart accessories, and Micropayments | Financial institutions can integrate IoT technology into smart accessories and facilitate micropayments. | IP-3,[29] |
| Sales | Financial institutions can simplify the reach to the customers. This convergence of IoT technology with advertising and sales strategies opens up new avenues for businesses to connect with customers in a more seamless and targeted manner | IP-5 |

4.3 Prerequisites

We also asked the interviewee to think about the essential prerequisites for implementing IoT in the Financial Industry. The most observed prerequisite was the “strong and secure integration” of IoT technology into the Financial Industry. This prerequisite consists of several sub-factors that were mentioned by different interview participants.

1. One of these elements is the successful integration of new technology into existing processes. Those processes and habits have been established over an extended period and

blending new technology with old processes demands extra attention. Therefore, IP-4 mentioned, *“to integrate this into the existing business processes of financial institutions, like banks and auditors”*.

2. Another requirement appears to be the establishment of a secure end-to-end communication channel. When incorporating IoT, communication channels must maintain integrity, ensuring the confidentiality of data and remaining resistant to fraudulent activities. IP-4 brought up *“a secure end-to-end communications channel, guaranteeing the authenticity, integrity, and confidentiality of data”*.
3. Strong connectivity infrastructure is also important based on interview results. A solid connectivity infrastructure forms the foundation for any successful transformation initiative. This includes high-speed internet access, stable network connectivity, and the ability to seamlessly connect devices, systems, and applications. A strong infrastructure ensures efficient and uninterrupted data transmission, enabling the smooth functioning of digital processes and interactions. IP-6 talked about *“The prerequisite for transformation is undoubtedly a strong connectivity infrastructure, good solution providers and an organizational perspective that is open to transformation.”*
4. Lastly, 5G expansion can promote this integration. It can provide high-speed, low-latency connectivity which creates an ecosystem ripe for innovation, efficiency, and enhanced services. IP-5 mentioned “5G expansion in public areas” can result in faster and more secure data transmission.

The second most observed factor was the importance of Knowledge in the field meaning that to successfully adopt and utilize IoT technology, organizations require knowledgeable employees and managers who possess a deep understanding of the technology and its implications.

1. Knowledgeable experts are crucial for successful application of IoT technologies. Their expertise and understanding of IoT principles, technologies, and best practices are essential for designing, implementing, and managing IoT solutions effectively. IP-1 mentioned *“Firstly, Individuals have to be knowledgeable enough. It's not ultimately going to be only the IoT. It is also going to be aligned with artificial intelligence or machine learning. Individuals have to be knowledgeable about the programming, so they have to design a data pipeline where the persons with information can get to know”*. Similarly IP-7 said *“You have to have enough resources, meaning you have to have enough funds, then you have to have enough human capital that can work with those devices”*. IP-8 talked about *“Expert team from the same nations, from the same region at least, so that they can really get to know the consumer behaviors and the regulations by their terms, to have a strong partnership.”*
2. Experienced managers play a crucial role in simplifying the adoption of IoT within organizations. Their expertise, leadership, and strategic intelligence are vital in ensuring a smooth and successful integration of IoT technology into existing operations. IP-7

mentioned that *“Management should also have this expertise in the field because, well, that usually plays a crucial role”*.

3. Awareness should also be built to understand the capacity of IoT Technology. IP-3 explained that *“So that awareness needs to be built up along the way as information is being gathered, processed and you know, upon. And the question is how far you can go automated and where a manual process kicks in, where a human being needs to be present to do this Integration is very important and how big”*

Some interviewees draw attention to the Market need as well. Understanding the market need involves recognizing and addressing the specific demands, challenges, and opportunities that exist within the target market. Such as IP-3 explained *“there needs to be a demand and they need to have new services that make sense for the market where they act in. It could look differently in Africa versus Western Europe versus Eastern Europe versus Nordics, if we compare to Nordics, who has been quite a leader in adopting cashless transactions”*. Additionally IP-7 said *“As a consultant, my typical answer would be you have to understand what you are using it for. So if you introduced IoT devices just for the sake of getting on top of the trend, well, most probably that's not going to work”*. IP-8 also explained that understanding customer behavior and their need is important *“You may have the most innovative IoT product, but it may never serve for the needs of the country. If there is no penetration, it can be failed due to having different types of consumer behavior in the market”*.

Regulation seemed to be another important factor for adopting IoT. The evolving regulatory landscape plays a significant role in shaping the implementation, deployment, and operation of IoT solutions. IP-3 stated that *“Legislation to allow new technologies, allow new services to come into play. So there are important actors to regulate, to enforce adoption. I think that regardless if it's IoT or not, legislation forces companies to offer certain types of services to eliminate some problems, like the more cash it's in our society, the higher risk is for bank robbery or shop robbery. That is one of the mantras in the Nordics to eliminate these robberies is to eliminate the cash from the society and also to eliminate the black market.”*

IP-8 also supported this by saying *“First of all, the regulation of the country. I mean anything the company or banking company at least, I mean I'm talking about my industry they have to be aware of the regulations and adapt their products and their conditions, the consequences on basis of the regulation of each country”*.

Interviewees emphasized the importance of implementing robust security measures to prevent fraud cases and ensure the accuracy and integrity of the system. IP-1 said that *“the device has to be trained as sufficient in all the cases for example before the implementation in real time it has to be trained on all scenarios that can be happened in certain places”*. Additionally IP-8 mentioned *“they should make sure that the data that they are having or the products that they are having are not being a victim of any fraud attacks, terror attacks”*. IP-1 also think *“Because*

cybersecurity is if anywhere in the future, if the financial industry is going to introduce IoT in the financial sector, then cybersecurity will be act as armor into the services. Because as we spoke about that with technology, new technology implementing, new challenges are coming across.” Additionally, IP-3 mentioned consent management and security maintenance *“And combining a standard with a high degree level of security ability to conduct this consent management, I think is an important enabler to conduct financial transactions if the securities not there with a high degree of authentication control”*

IoT technology acceptance and success requires standardization. It includes the creation and adoption of industry-wide standards, protocols, and frameworks to guarantee the interoperability, compatibility, and seamless integration of IoT systems, devices, and applications. IP-3 pointed out *“Obviously, one is the confidence in the backbone that will facilitate this brokering, because there will be so many parties that need to get together under some type of standardized forum, standardized specification. And if multiple standards are being adopted, very fragmented. Will create a very heterogeneous, bloated market environment which will limit the possibilities to conduct because we are more global today, global citizens, traveling, et cetera”*. IP-4 also mentioned about *“harmonization of data, just like there have been standards for financial reporting (like GAAP)”*.

Lastly, For successful integration, the availability of various high-quality hardware components plays a crucial role. The availability of reliable hardware components is a vital aspect to consider when aiming for the successful integration of IoT technology. IP-7 said that *“The secondary factor would be the supply of the devices in the market”*.

| # | Prerequisties | Sub-elements | Description | Mentioned |
|---|-------------------------------|---|--|------------------------|
| 1 | Strong and secure integration | Successful adaptation to the existing processes | The successful integration of IoT technology in the Financial Industry requires strong and secure integration, including considerations for existing processes, secure data communication, robust connectivity infrastructure, and the potential benefits of 5G expansion. | IP-4, IP-5, IP-6 |
| | | Secure end-to-end communications | | |
| | | Strong connectivity infrastructure | | |
| | | 5G expansion | | |
| 2 | Knowledge | Knowledgeable experts | Knowledge is a key factor in the successful adoption and utilization of IoT technology. Organizations need knowledgeable employees, skilled managers, and awareness of IoT's capabilities and limitations to maximize | IP-1, IP-3, IP-7, IP-8 |
| | | Experienced managers | | |
| | | Awareness | | |

| | | | | |
|---|---------------------------|--|--|-------------------|
| | | | the benefits and overcome challenges in implementing IoT solutions. | |
| 3 | Market need | | Understanding the market need requires a comprehensive understanding of the specific demands, challenges, and opportunities within the target market. It involves recognizing the unique requirements and preferences of customers, as well as the obstacles and potential areas for growth or improvement within the market. | IP-3, IP-7, IP-8, |
| 4 | Regulation | | The ever-evolving regulatory landscape plays a significant role in influencing the implementation, deployment, and operation of IoT solutions. Compliance with regulations is essential to ensure data privacy, security, and ethical use of IoT technologies. | IP-3, IP-8 |
| 5 | Security measure | | Strong security measures are crucial for safeguarding sensitive data, protecting against unauthorized access, and mitigating potential risks and vulnerabilities. | IP-1, IP-3, IP-8 |
| 6 | Standardization | | Standardization is a crucial factor. This involves the development and adoption of industry-wide standards, protocols, and frameworks that ensure the interoperability, compatibility, and seamless integration of IoT systems, devices, and applications. | IP-3, IP-4 |
| 7 | Availability of resources | | The reliability, performance, and compatibility of hardware components greatly impact the overall functionality and effectiveness of IoT deployments. By ensuring the availability of diverse and high-quality hardware options, organizations can select components that best align with their specific requirements and use cases. | IP-7 |

4.4 The impact of potential use cases

In this section we aim to express findings for *RQ2:How can the potential use cases of IoT impact financial institutions and customers?* The exploration of these use cases sheds light on the impact of IoT on Financial institutions and customers in the ecosystem.

Interview results showed that one of the impacts of the implementation of IoT in the Financial Industry is on the customer experience. It can have several impacts from different perspectives which were listed below.

1. Decision-making seemed to be one potential impact area meaning that by the implementation of IoT, customers can utilize those technologies in the decision-making process. IP-3 claimed that the *“customer relationship field definitely is the one between systems who will benefit as well. I think it's important and this real-time capability between systems is very important. Ingoing information, outgoing information and it's not only about capturing information, it's about processing it and making decisions about it.”*.
2. Information access meaning IoT can enable customers to access a wealth of information easily and conveniently, providing them with valuable insights and empowering them to make informed financial decisions. IP-1 mentioned that *“It's definitely going to be easy for the customers with the introduction of IoT in the financial industry because it definitely has multifunctions. For example, even though we have access to information like online availability of doing things all the time. But still, there are some limitations like visiting a branch after 05:00 p.m.”*
3. Advertising seemed to be another important aspect to consider when examining the impact of IoT on customer experience and the potential for customers to be subjected to too much exposure to advertising which can have an impact on customer experience in different ways. IP-1 *“If home cleaning devices have access to financial services that means they can look into your home. For example, you don't have a microwave and those data have been sent to the company of the home automotive merchant which is combined with the credit card and they will ask you to buy a microwave and somehow they are providing some advertisement”*.
4. Fastened loan approval can be another impact on customers' experience. Traditional loan application processes can be time-consuming and tedious, causing delays and frustration for customers. However, IoT can streamline and expedite the loan approval process, offering a more efficient and seamless experience for customers. IP-4 explained that *“If customers are for example companies needing a bank loan, I think especially in emerging markets and developing countries, having IoT technology measure collaterals is directly affecting the customer. It would, however, most likely increase access for these companies to get bank loans, and lead to lower interest rates.”* IP-5 also mentioned *“Should increase small amounts of lending frequency for consumer goods and services”*

Interviewees mentioned that IoT technology might have the potential to impact the Competitiveness of companies by enhancing operational efficiency, improving customer experiences, enabling data-driven insights, fostering innovation, and optimizing the costs. IP-5 said, *“It is increasing competitiveness”*.

1. Improved Efficiency is one of the expected impacts of IoT in the Financial Industry. IP-6 thinks the financial institutions will benefit *“such as asset security, building management, and branch management, financial institutions' data in the physical world can be collected and processes can be made more efficient.”*.
2. Improved customer analysis by collecting and analyzing data from IoT devices, financial institutions can gain valuable insights into customer preferences, needs, and behaviors. IP-5 said that *“the IoT can be used for the prediction of user behavior”* and additionally IP-7 expects that IoT can help to observe *“the customer when enters the branch office and then how much time he spends there. What areas does the person go to? What exactly does he do? Let's say with the ATM what operations are there on the ATM side?”* and also observe the branch capacity. He said *“They can see which employee is the most loaded due to the heavy traffic of the consumers. Well, again, this is the client-facing employees. But then there are these back-office employees who might benefit from IoT implementation”*. It can also *“minimize the time that the client takes on each visit and therefore affect clients and peer score”* based on IP-7.

Another impactful application of IoT technology in the financial industry is its potential to facilitate Seamless and secure microtransactions. IoT-enabled devices can facilitate automated and frictionless transactions, eliminating the need for physical cards or manual input of payment details. With embedded sensors, authentication protocols, and secure communication channels, IoT devices can ensure the privacy and integrity of microtransactions, providing a convenient and secure experience for both customers and financial institutions. IP-3 mentioned *“I do believe the micropayment things would simplify the use, eliminating in particular how having a physical credit card with you it will be and become more universal almost that you can choose which gadget you want. If it's a necklace, if it's a bracelet, if it's part of your watch, I think. All individuals have their own preferences and own conditions of what they can get hold of and what they feel. It's part of their lifestyle”*.

IoT can impact the digitalization level of financial institutions. By leveraging IoT capabilities, financial institutions can accelerate their digital transformation efforts and unlock new opportunities for growth and innovation. IP-1 pointed out that *“Also with digitalization, especially in Thailand, and in Estonia itself, it's a digitalized country but they are very far away branches when the person has to go over there. But with IoT, there are some software or programs that can be introduced in finance where the person has no need to go into a branch at all and solve the issues”*.

Besides all mentioned impacts IP-4 explained the potential impact of IoT on financial institutions, *“I wouldn't say it's transformative; those hype terms have been used extensively in the past and the internet of things is not delivering true transformations. The Internet of Things is just internet connectivity with things instead of humans. It enables better and more automated*

data collection that can be of substantial help in new business processes, cost reductions, and improvements of data quality and financial reports.”

| # | Impact area | Sub-area | Effect | Definition | Mentioned |
|---|----------------------------|----------------------------|-----------------|---|------------|
| 1 | Customer experience | Decision-making | Positive | IoT can impact customers' decision-making process. Its ability to capture and process data can lead to better decision making | IP-3 |
| | | Information access | Positive | IoT can impact information access by providing real-time data, enabling remote monitoring and control. Additionally impact on the availability of doing things all the time | IP-1 |
| | | Loan approval | Positive | IoT can impact on Loan approval process by providing transparency of data and access to the customers' spending behavior. It can increase and fasten the loan approval process. | IP-4, IP-5 |
| | | Advertising | Negative | IoT can impact on customer experience with the possibility of customers being excessively exposed to advertisements which can result in frustration and a detrimental experience. | IP-1 |
| 2 | Competition | Efficiency | Positive | IoT can impact asset security, building management, and branch management, financial institutions' data in the physical world. Those data can be collected and processed to make financial institutions more efficient. | IP-6 |
| | | Customers' analysis | Positive | Financial institutions can gain valuable insights into customer preferences, needs, and behaviors. Additionally when customers enter the branch office and then how much time he spends there. What areas does the person go to? What exactly does he do? | IP-5, IP-7 |
| 3 | Micro-transactions | - | Positive | IoT can facilitate seamless and secure microtransactions by eliminating the need of having a physical credit card with you. Customers can decide which gadget or accessories they want to carry out micro transactions. | IP-3 |

| | | | | | |
|---|-----------------------|---|-----------------|---|------|
| 4 | Digitalization | - | Positive | IoT can impact on capabilities of financial institutions by accelerating their digital transformation efforts and unlocking new opportunities for growth and innovation | IP-1 |
|---|-----------------------|---|-----------------|---|------|

4.5 The value of IoT

This section focused on highlighting the value of adopting IoT in the financial industry based on *RQ3: How could IoT bring value to financial products and services?* The primary objective of the investigation was to gain insights into the potential value of IoT technology in the financial industry. Additionally, we aimed to identify the specific contributions that IoT devices can offer. We also assessed the magnitude of this value and explored the feasibility of implementing various use cases.

First of all, we asked for interviewee evaluation of the value that these use cases bring to financial institutions and their customers. Starting with financial institutions, one of the potential values of adopting IoT technology seemed to be Automation. The integration of IoT devices and systems allows for the automation of various processes and tasks, leading to increased efficiency, accuracy, and cost savings. IP-4 mentioned *“For banks, getting automated and streaming insights from lenders, instead of manually performing checks. Those manual checks are expensive. For auditors, matching measured inventory with reported inventory numbers is another check to verify reports.”* IP-4 also explained that *“The market of lending is huge, and is definitely upcoming in emerging markets where collateral is a challenge today. Even in developed markets, reducing risk for creditors or reducing interest rates by knowing exactly what’s going on in the company is very valuable. The market for ESG reporting is rapidly increasing and I expect all publicly traded companies to be required to produce audited reports in the future. For many companies, this requires automated measurements using IoT technology”*

Another potential value of IoT technology seemed to be Cost Optimization and Revenue Generation through improved efficiency and better customer experience such as IP-7 said *“First, the client-facing part of the business and the internal back office part of the business. Those are not mutually exclusive and these are not all exhaustive cases. But the motivation here is that the client-facing business is the revenue-generating part of the business. Therefore, optimizing the processes of the revenue-facing side would be most probably of the top priority for the bank. On the other hand, the back office is the part of the business that's generating most of the costs, like salaries, investments into the infrastructure, investments into the capital, et cetera. Therefore, if the IoT devices can optimize the cost or at least reduce the frauds or the risks associated with*

transferring money, the bank would be also interested in banks would be also interested in those applications as well, I believe”

According to interviewees, the adoption of IoT technology in the financial industry can positively impact the Brand perception of financial institutions by improving Customer service meaning that optimizing the customer-facing aspects of the business through IoT can enhance the way customers utilize financial services and increase customer satisfaction. IP-7 mentioned that *“You are able to affect the consumer journey by putting more employees on the spots that are heavily loaded parts. And second, you are able also to, what do you call it, minimize the time that the client takes on each visit and therefore affect clients and peer scores. Meaning the brand perception for the bank would be better there, and therefore well, yeah, the brand perception is an important point here.”*

Based on the previous research work, IoT applications were predicted to bring changes in the Financial Product Planning, Management, Marketing, and quality of services. IoT enables financial institutions to track all consumer activities and collect data from sources like mobile apps, which can be used to launch more targeted and personalized service offerings. The data collected can provide insights into the needs and desires of the client, allowing financial institutions to present solutions tailored to their individual preferences. Additionally, the record of past activities of the customer can help service representatives provide better solutions and improve overall customer satisfaction.

Another expected value for financial institutions resulting from the adoption of IoT technology, as highlighted by interviewees, is the Increased Frequency of Loans. The integration of IoT devices and data analytics can positively impact the loan processes and provide opportunities for financial institutions. Moreover, IP-4 thinks *“The market of lending is huge, and is definitely upcoming in emerging markets where collateral is a challenge today. Even in developed markets, reducing risk for creditors or reducing interest rates by knowing exactly what’s going on in the company is very valuable”*.

We also explored the impact of IoT on customer experiences and financial services, which helped us to gain insights into the benefits that customers can expect from the adoption of IoT in the financial industry. One of the potential value propositions of IoT technology for customers, as highlighted by interviewees, is the benefit of automated payments. IP-1 pointed out *“Looking ahead, the future of finance may involve innovations in transactional technology, such as how transactions are processed in stores, grocery stores, or banks. So maybe my idea is not correct up to the mark, but some way it's going to be used in the future to make smooth transactions or maybe provide better customer services in the financial Industry.”*

Another potential value for customers resulting from the adoption of IoT technology is better access to loans. IoT can contribute to improving the loan application and approval process, providing customers with enhanced access to financial assistance. IP-8 discussed that *“if*

customers never had credit before that is mentioned in the data system of the central bank of reservation. Without having a credit history their just payment behaviors monthly paid on utilities, e-commerce, post virtual or physical doesn't matter in the retail sector they can already be rewarded by credit with no limits. It gives much more opportunities to entrepreneurs as well to get business credit"

After discussing the potential value of IoT in the financial industry, we proceeded to inquire whether the interviewees could identify any specific IoT devices that stood out in this context. IP-1 pointed out a smart camera *"A digital camera where the information can be captured, stored and provided to the banking system about the customers."* For IP-3 *"I do believe it is the point of the sales terminal where remote transactions make personnel able to be mobile and conduct the payment transaction anywhere on the shop floor."* IP-5 mentioned *"Smartphones and compact payment terminals"*. Asset tracking technology seemed to be another IoT device that was expected to bring value based on the IP-6 perspective. He said *"Since asset security is the top priority, I think it is asset tracking."* IP-7 mentioned *"If there are IoT devices that are able to reduce risks associated with frauds and security, those would be the most valuable devices for the banks because well, yeah, the banks usually lose lots of money because of the fraud cases."* In contrast, IP-2 said that, *"I think it's mostly about the Apple payer. So it's not about the device, it's about the service"*.

We asked the interviewee to describe the magnitude of the value to understand the role of IoT technology in the Financial Industry. IP-1 thinks *"I guess it is going to be valuable. One way or the way it's going to happen in the future somehow"*. IP-3 expects the value to be huge. He expressed *"It's billions. I'm sure it's billions. Everybody, you everybody has a stake in this. If you're a technology vendor, I think it's a multibillion-dollar industry. If we are talking about an actor in the ecosystem where the model is that you take 0.1% out of the financial transaction and know how much the world transacts on a daily basis. There is a big. The Opportunities here are really huge"*. IP-6 said *"I expect at least a 20% reduction in energy consumption, a 15% reduction in customer waiting time, and a 50% performance improvement in resource wastage. However, these figures are purely subjective"*. However, IP-7 explained *"IoT devices could be cutting costs and generating additional incremental revenue. But well, from my perspective, I don't believe those would be as. And those won't be the disruptors in the industry."* Similarly, IP4 mentioned that *"I wouldn't say it's transformative; those hype terms have been used extensively in the past and the Internet of things is not delivering true transformations. The Internet of Things is just internet connectivity with things instead of humans. It enables better and more automated data collection that can be of substantial help in new business processes, cost reductions, and improvements of data quality and financial reports"*. IP-2 discussed that the value is *"not big enough. I would say it's only for people above 18 years and less than 60 years. That's the age group who will benefit"*.

| # | Value | To | Definition | Mentioned |
|---|--|------------------------|--|-----------|
| 1 | Automation | Financial institutions | The integration of IoT devices and systems allows for the automation of various processes and tasks, leading to increased efficiency, accuracy, and cost savings. | IP-4 |
| 2 | Cost Optimization and Revenue Generation | Financial institutions | The integration of IoT devices and systems can improve efficiency and better customer experience which leads to Cost Optimization and Revenue Generation | IP-7 |
| 3 | Brand perception | Financial institutions | The integration of IoT devices can provide value of optimizing the customer-facing aspects of the business which enhance the way customers utilize financial services and increase customer satisfaction meaning the brand perception for the bank would be better | IP-7 |
| 4 | Increased Frequency of Loans | Financial institutions | The integration of IoT technology can provide value to loan processes which is also revenue-generating part of the financial institutions. Reducing risk for creditors or lowering interest rates by knowing exactly what's going on in the company and customer. | IP-4 |
| 5 | Automated payment | Customer | The integration of IoT technology can provide the value of automating payments for customers such as how transactions are processed in stores, grocery stores, or banks. | IP-1 |
| 6 | Access to Loans | Customer | The integration of IoT technology can provide value in improved loan application and approval processes which provides customers with enhanced access to financial assistance. Without having a credit history their just payment behaviors are monthly paid on utilities, on e-commerce, post virtual or physical doesn't matter in the retail sector they can already be rewarded by credit with no limits. It gives much more opportunities to entrepreneurs as well to get business credit | IP8 |

4.6 The Challenges of IoT

This section focused on discussing the challenges associated with implementing IoT in the financial industry. Building upon previous research work, we explored the various aspects that make the adoption of IoT in the financial sector challenging.

One of the most frequently mentioned challenges associated with adopting IoT technology in the financial industry is Privacy issues. During the interviews, privacy concerns emerged as a significant consideration when implementing IoT devices and leveraging their capabilities.

IP-7 explained *“I don't know use cases for improving the loan distribution decisions because if you are trying to give a loan to a person, you have to know this person. But to know this person, again, as we said, we are able to introduce those IoT devices but at the same time you are infringing these persons, this individual's personal space and I'm not sure that's even lawful.”*

Additionally, IP-7 expects the application of IoT to happen in case of dealing with sensitive issues, *“I actually believe those would happen, at least not for you as a client of the bank, but on the bank's premises. The matter of banks is a sensitive topic for everyone, because you're dealing with the money of people, right, the money of different companies. Therefore banking is heavily regulated, I think, in all parts of the world. And therefore you're not able to just introduce threat-posing devices into your bank premises without the acceptance of, let's say, a regulator in the National Bank”*. Additionally IP-1 explained *“Nowadays we have found something similar in our mobile phones that we and my friends are discussing something and those same information are showing us on the mobile or phone like they are recording our conversation.*

We don't know exactly how they come to know what we are thinking. Okay, so I guess it has some disadvantages. But still, they are not larger. They are still using it for the promotion of the product.”

Another concern that emerged during interviews regarding IoT adoption in the financial industry was Security issues. IoT devices are connected to networks, making them potential entry points for attacks. IP-3 said *“Cybersecurity is a challenge. It's an area that is probably still neglected, and you cannot put too much effort into cybersecurity. It's a daily threat, I do believe, not that I have personal experience, but the observation I had, and I think there is a consensus is that every day, every company is in some shape and form, unknowingly being attacked or even hacked in some shape and form”*. Additionally, IP-4 mentioned *“Another challenge is ensuring the end-to-end security and creating confidence with data consumers that the data provides a whole and realistic view”*. IP-3 also said *“what is sensitive is the fact that we place our trust in the bank. It's our money that we have earned by sweat, tears, and blood.*

And if we have an issue and we have difficulty with someone to consult with and sit in queues for hours and getting quite deep active answers or speaking with a robot, I think that's quite a sensitive, delicate area”.

Besides interviewees, cybersecurity was discussed in previous study works as well[32]. The

Major cybersecurity threats in the banking and FinTech industries can occur due to several reasons such as unencrypted data. The lack of proper encryption can lead to data breaches where stolen data can be immediately accessed. Unprotected third-party services can be possible attack points as well. Due to the widespread use of internet services, cyber attackers can easily access the data of targeted users through unprotected third-party services. Another one can be unsecured mobile banking. With the increase in mobile banking users, mobile hackers can easily access data due to the short computation time. To secure mobile banking data, cryptography methods of encryption and decryption are used. Additionally, anti-money laundering (AML) monitoring systems can generate false positives, pointing out a fake activity that requires an analyst to determine whether it is legitimate. Lastly, The huge volume of financial data increases the risk of security breaches for customers, especially during nighttime hours. It's important to be aware of the potential for breaches in the banking and FinTech sectors.

Regulation is another challenge identified during the interviews regarding the adoption of IoT in the financial industry. Compliance with regulatory requirements is a crucial consideration when implementing IoT devices and leveraging their capabilities. IP-2 brought up “It's difficult because the financial industry has GDPR and regulatory requirements so you cannot collect all the data.”

Regulations were discussed in previous research work as well[38]. The IoT market is still in its early stages and not yet prepared for large-scale deployment. The uncertain business environment and lack of government regulations, policies, or other indicators are the primary reasons for this, leaving entrepreneurs and companies uncertain about how government actions may affect future business opportunities.

Accuracy and reliability can be another regarding the adoption of IoT in the financial industry. Ensuring the accuracy and reliability of IoT technology is crucial for financial institutions to maintain trust in their operations and decision-making processes. Based on the interviewee results, IP-1 mentioned Data accuracy as one potential challenge by saying “*First, for IoT technology to be effective, it must be trained on accurate data, even in noisy or imperfect environments. For instance, if a camera is fixed on a person standing in front of it but obscured by other moving objects, the camera must still be able to accurately identify the person.*”

This may occur due to unforeseen incidents or limitations in the software's ability to handle anomalies in real time. Inaccurate data capture can result in unreliable analytics that cannot support informed decision-making. This challenge can significantly impact industry users and customers and should be addressed to ensure the success of IoT implementations.

Another challenge that emerged during the interviews regarding the adoption of IoT in the financial industry is the level of managerial interest and engagement. The interest and commitment of managers play a crucial role in driving successful IoT implementations and

realizing the potential benefits. IP-6 specified acceptance of IoT implementation by managers of financial institutions *“I think the biggest challenge is managers' willingness to adapt to innovation. The physical world that comes into contact with customers is waiting for us to dig up their data.”*

Lack of standardization seemed as another significant challenge meaning that the absence of widely accepted standards and protocols can impede the interoperability, compatibility, and scalability of IoT solutions. IP-3 pointed out that *“lack of standardization has been one of the blockers. And if there are multiple standards being adopted, very fragmented. It will create a very heterogeneous, bloated market environment which will limit the possibilities to conduct because we are more global today, global citizens, traveling, and limit the local market where you live your daily life”*

Lack of unified standards[31]: The absence of a unified standard for IoT is a significant challenge, and achieving industry-wide acceptance of one standard is difficult. This lack of unified standards can lead to functional flaws in IoT devices

Unrealistic expectations emerged as another significant challenge during the interviews regarding the adoption of IoT in the financial industry. It is important to manage expectations and have a realistic understanding of what IoT can and cannot deliver. IP-4 mentioned about setting the expectation about the role of IoT in the industry, *“I think that fintech needs to go through the Internet of things hype cycle first and make sure the expectations are realistic. The Internet of things is just a tool, not a full-blown solution.”*

The scarcity of resources emerged as another significant challenge during the interviews regarding the adoption of IoT in the financial industry. Limited resources, including financial, technological, and human resources, can impede the successful implementation and deployment of IoT solutions. IP-7 Furthermore, “scarcity of human resources”, “scarcity of supply”, “lack of financial support” and lastly “not understanding the trend” are potential challenges

In 2019, Sadanand Vijay Kumar stated potential obstacles of IoT Implementation[31].

Lack of Customer Empathy: Many IoT service providers fail to define the problem statement clearly, which can impact the success of the implementation. Understanding how an IoT solution can improve efficiency, customer satisfaction, and productivity, in the long run, is crucial. The research emphasizes that understanding the customer's problem statement is critical to the success of an IoT implementation and should be a priority for IoT consultants.

Hardware compatibility problems can arise in IoT implementations when data is captured from different sensors and PLCs (Programmable logic controllers) connected to IoT gateways for transmission to the cloud. To ensure successful implementation, businesses must carefully identify the equipment, hardware, and legacy machines based on their goals and desired outcomes. The challenge becomes more critical when legacy machines lack the necessary PLCs

and sensors, which may require the addition of external sensors. However, this solution may not be entirely reliable and can present a significant challenge.

Analytical tool: A significant challenge in IoT implementation is deriving actionable insights from the vast amount of collected data. To achieve this, a high-performance analytics platform is required to handle the data processing, cleansing, and representation. It is crucial for data analytics partners to consider the extensibility of the IoT implementation architecture, allowing for the addition of real-time or predictive analytics in the future. By creating adequate space for such analytics, this challenge can be addressed and overcome, ensuring the successful implementation of the IoT solution.

Aznag & Tahanout also mentioned the challenges of these technologies such as Data density[29]. The abundance of data provided by the Internet of Things can give customers more options, but processing all this data can lead to anxiety, confusion, and indecisiveness. However, storing and securing large amounts of data can also be costly, and organizations may not have the resources to test for inaccuracies, resulting in lower data quality.

The interviewees were asked to provide their predictions regarding the timeline for the adoption of IoT. IP-1 predicts that *“They are going to happen in real-time in the future, like maybe in a couple of years.”*

IP-3 highlighted the distinction between the level of technological advancement across different nations and the resulting variation in the timeline for adopting those technologies. IP-3 explained that *“The adoption is happening and it's going into a more digital world but the speed is very different and I think the opportunity is not even though the adoption rate is higher in the Western world, the industrialized countries, the most modern countries we are talking about a forgotten world like Eastern Europe, most population in Asia, Africa and Latin America is untapped. It's going to happen over and it's going to take decades, decades, depending on which markets you talk about. Ah, decades in Sweden as one of the leading countries in the world. If we talk about countries in Africa, they have their own journey and adoption, and probably the type of services and the conditions will look different than one in Sweden. It's going to happen over it's going to take decades, decades, depending on which markets you talk about.”*

On the other hand, IP-4 expects the changes to happen over a decade, *“I think both use cases are very likely; measuring collateral more likely in emerging markets, while auditing ESG reports in developed markets in a 10-year time frame.”* Additionally, IP-4 mentioned that *“The technology is mostly there. I wouldn't be able to comment on how long it takes for these solutions to materialize in the financial sector. We have been involved in some proof of concepts already and we know things are cooking, but we probably need innovative institutions to set the example, likely accelerated by regulations.”*

While IP-5 was not able to anticipate the timeframe but expects the adoption to happen. IP-6 said *“I believe that 90% of financial institutions in OECD will use digital transformation solutions with IoT in the next 5 years.”* Furthermore, IP-7 provided insights into the varying levels of adoption based on the size of financial institutions, *“there are more conservative banks, and the*

bigger the bank, the more conservative it becomes. And therefore, I believe for bigger banks, it would take, let's say, three to five years to introduce those devices, but for smaller and more risk-tolerant banks, it would take just a year or two.”

| # | Challenges/Threads | Definition | Mentioned |
|---|---------------------------------|---|-----------------|
| 1 | Privacy | IoT technology can raise privacy concerns due to intervention in an individual's personal space and capture of personal information | IP-1, IP-7 |
| 2 | Security | IoT technology introduces security challenges due to its connectivity to the internet, which expands the attack surface and creates vulnerabilities that can be exploited. | IP-3, IP-4,[32] |
| 3 | Regulation | Regulations can impose limitations on the potential of IoT technology and its capabilities due to regulations on data that are allowed to capture | IP-2,[38] |
| 4 | Accuracy and reliability | Maintaining trust in the operations and decision-making processes of financial institutions relies heavily on ensuring the accuracy and reliability of IoT technology. Despite having a robust and secure system, there is still a possibility of incorrect data capture | IP-1 |
| 5 | Managerial interest | Managers' openness to adapt to innovation and their active involvement in the process | IP-6 |
| 6 | Lack of standardization | The absence of widely accepted standards and protocols poses a significant challenge, as it leads to a lack of standardization within the IoT landscape. This lack of standardization can hinder the interoperability, compatibility, and scalability of IoT solutions. | [31],IP-3 |
| 7 | Unrealistic expectations | Unrealistic expectations can arise, and it is essential to educate stakeholders about what IoT can truly deliver and set achievable goals for implementation. | [31], IP-4 |
| 8 | Scarcity of resources | IoT solutions can be hindered by limited resources, including financial constraints, technological limitations, and a scarcity of human resources. These resource limitations pose challenges in acquiring the necessary infrastructure, investing in the required technologies, and securing skilled personnel with the expertise to effectively implement and manage IoT initiatives. | IP-7, [31] |

5 Discussion

In this section, we aim to discuss the findings from the interviews and address the research questions that guided the study. By observing the interview responses and synthesizing the information gathered, potential use cases in the financial industry will be categorized by considering the capabilities, prerequisites, impact, value, and challenges of the IoT. This section presents a summary of the findings and their alignment with the research questions.

The first interview question is *“What capabilities of IoT technology can enable the use cases in the Financial Industry?”*. The goal was to understand what capabilities of IoT can facilitate the potential use cases in the Financial industry. To answer this question, interview results were used as the literature review did not reveal such information. As a capability and the characteristics of IoT technology, we observed shared and unique perspectives. These include the ability to gather data through sensors, fast processing capabilities, efficient communication, tracking capabilities, security measures, data sharing capabilities, the low cost of implementing the technology, and the potential for digitalization. The most observed characteristics were data reading and fast processing capabilities. It can be understood that these attributes are not exclusive to the Financial industry. In Section 2.1, use cases within the Manufacturing sector were outlined, the same capabilities discussed here serve as elements for those scenarios as well.

While the IoT utilization in the Manufacturing sector is notably higher, it is noteworthy that the observed capabilities can also facilitate certain use cases within the Financial sector which was reflected in following research question.

The second research question is *“What are the potential use cases of IoT in the Financial industry?”*. To answer this question, a literature review and interview results were used. The investigation of the use case gave us various results. Firstly, it was noted that the majority of the identified use cases were elaborated upon in both the existing literature and the outcomes of interviews. These encompass Anti-money laundering, Know your customer program, Security enhancements, Capacity management, Loan automation, and the incorporation of Smart accessories in micropayments. The possible explanation for this recurring can be being inherently critical and necessary areas of application, as they address major concerns within the Financial sector.

Furthermore, the interviews with participants revealed a collection of use cases that had not been previously documented. These novel applications encompassed the domains of Maintaining Security Measures, Automated Reporting, Automated Payments, and Sales. The absence of these use cases in prior literature raises intriguing considerations, potentially stemming from various factors that warrant exploration. The notion of Maintaining Security Measures delves into the establishment of a secure environment through multifaceted tracking methods, including asset tracking, branch monitoring, and customer tracking. This use case might have been overlooked due to the presence of alternative security measures or an emphasis on different aspects of

security such as cyber-attacks, potentially relegating physical security concerns to a secondary focus. Automated Reporting and Sales emerged as distinctive propositions, potentially this is because of the specialized knowledge and expertise of the interviewees. These use cases could have eluded previous work due to their requiring insights from industry experts.

Lastly, the Automated Payment concept, is a scenario in which transactions transpire seamlessly, such as in grocery stores, without necessitating active payment interactions. This emergence might be attributed recently based on the growing adoption of contactless payment technologies, which reshape the dynamics of payment transactions.

Additionally, we have also seen some use cases that haven't been described while the discussion such as Smart home assistants, Leasing Finance Automation, and Risk Mitigation in Trade Finance. Those use cases don't seem to be correlated thus there might be different reasons for not being mentioned. Although we can hear about smart home assistants, the belief for them to be part of Financial services might not be developed yet. The other possible use cases might be specific areas that required specific expertise.

Looking at the potential use cases, many of the identified use cases appeared to be focused on the applications within financial institutions rather than directly impacting customers.

The next research question "*What are the prerequisites to backup IoT implementation?*" was investigated to understand what is required to implement the use cases we discussed.

Those prerequisites can also give us signals about the current market state and what needs to be improved. Interviewees talked about Strong and secure integration, Knowledge, Market need, Regulation, Security measure, Standardization, and Availability of resources as requirements for successful integration. The most observed prerequisites were Knowledge, Strong and secure integration, Market need, and Security measures. Interestingly, in the literature review, we couldn't find much information about the prerequisites of IoT technology.

RQ4. How IoT devices will impact Financial Industry? Helped us to investigate the impact of the potential adoption of IoT in the Financial industry. Although most of the use cases were centered around financial institutions, it is important to recognize that the impact of IoT extends to customers as well. The most observed impacts were on Customer experience and the competitiveness of the Financial Institutions. As a positive impact, we have observed improvement in Customer experience, Competitiveness of the financial institutions, Seamless and secure microtransactions, and Digitalization. Among the various impacts we have examined, one aspect that might negatively affect customers has been detected which is potential targeted advertising. It is essential to recognize and address possible negative impacts to ensure a well-rounded understanding of the consequences of implementing IoT technology.

We found out that with the application of IoT devices, Customer experience can improve in various aspects such as Decision making, Access to information, and Loan approval.

On the other hand, it can also impact on competitiveness level of Financial institutions from various perspectives such as Improved efficiency and improved customer analysis. It seems that

the vast amount of data generated by IoT devices enables financial institutions to gain deeper insights into customer behavior, operational performance, and digitalization. With this data-driven approach, financial institutions can enhance and develop personalized products and services for their customers, provide better information access, and boost the performance of institutions. We also have to consider that the impact of IoT might not be transformative supported by IP-4 and IP-7. Thus, setting clear expectations and defining what you want to achieve with IoT technology can significantly determine its impact. Properly defining the goals and objectives of implementing IoT solutions helps in identifying the specific areas that can benefit from this technology.

RQ5. *How could IoT bring value to financial products and services?* We have investigated various aspects including the potential values of the use cases, which IoT devices can bring value, and the feasibility of use cases.

We have seen various values of IoT technology, Automation, Cost optimization, and Revenue generation, improved Brand perception, and an increase in Loan frequency. The ability to extract data from the external and internal environment can greatly support the automation of manual tasks that are otherwise expensive and time-consuming. Tasks like measuring inventory levels or generating automated reports can be optimized through IoT-driven data collection and analysis. By leveraging IoT technology to gather real-time data from various sources, businesses can streamline processes, reduce human intervention, and eliminate the need for laborious manual efforts. This leads to increased efficiency, cost savings, and faster decision-making. Another value offered by IoT technology can be Cost optimization and Revenue generation, which can contribute to the financial performance of institutions. IoT devices can support cost optimization by streamlining processes, reducing operational expenses, and minimizing the risks associated with financial transactions, such as fraud and errors. Furthermore, IoT's data collection and analytics capabilities enable institutions to gain valuable insights into customer behavior, preferences, and location which contributes to Revenue Generation.

The implementation of IoT technology in the financial sector has the potential to enhance the brand perception of financial institutions by positively impacting customer service. By optimizing the customer-facing aspects of their operations through IoT, financial institutions can improve the delivery of financial services, resulting in higher customer satisfaction and an improved overall perception of their brand.

Another valuable outcome for financial institutions arising from the adoption of IoT technology is the increased frequency of loans. By integrating IoT devices and leveraging data analytics, financial institutions can positively impact their loan processes, creating opportunities for growth and profitability. By offering improved loan products and services, financial institutions can attract more borrowers, leading to a higher frequency of loan approvals. Moreover, IoT-powered data analytics can enable better risk assessment and credit scoring, allowing financial institutions to make informed lending decisions and minimize the likelihood of default. This improved risk management can lead to a reduction in credit collection efforts, resulting in cost savings and more efficient operations.

Other than the value of the use cases, we investigated which IoT technology can bring value the most. Participants highlighted smart cameras, point of the sales terminal, Smartphones and compact payment terminals, and Asset tracking technology.

Regarding the value of the IoT, interviewees explained various areas as well as the magnitude of it. However, it is important to note that there were differing perspectives among the participants regarding the magnitude of the value that IoT can bring. While some interviewees expressed high expectations and believed that IoT has the potential to revolutionize financial products and services, others had a more conservative outlook, suggesting that the value of IoT may not be as transformative as anticipated. A possible explanation might be the difference in the domain expertise.

During the literature review process, we observed that the focus was often more on explaining the specific use cases of IoT technology rather than emphasizing the value and impact of these use cases. While understanding the use cases is essential, it is equally crucial to highlight the significance and benefits they bring to various industries and stakeholders.

RQ6: What are the barriers that prevent the implementation of IoT applications in the financial sector? We have identified different challenges and threads such as Privacy, Security, Regulation, Accuracy and reliability, Managerial interest, Lack of standardization, Unrealistic expectations, Scarcity of resources, Lack of Customer Empathy, Hardware compatibility, Analytical tool, and Data density.

Among the aforementioned issues, privacy and security stand out as potential threats that come with the adoption of IoT technology. While connectivity can bring significant value to the financial industry, it also opens a gateway for potential attackers. Privacy concerns appeared as a new thread as we haven't detected it in the literature review.

Lack of standardization, Regulation, and scarcity of resources are external challenges that can potentially limit the widespread adoption of IoT technology in the financial industry. Lack of standardization can be a problem to the widespread adoption and globalization of the application. Moreover, government and regulatory institutions seemed to play a crucial role in navigating this landscape by striking a fine balance between protecting customer interests and fostering innovation. Effective regulation is necessary to ensure the responsible and secure use of IoT technology in financial services. By establishing clear guidelines and standards, regulators can address concerns related to data privacy, security, and ethical practices. Apart from regulation, another external challenge that can limit the potential adoption of IoT technology in the financial industry is the scarcity of human resources in the labor market. As IoT technology becomes more prevalent, there is a growing demand for skilled professionals who can develop, implement, and manage IoT solutions.

Accuracy and reliability, Managerial interest, Unrealistic expectations, Lack of Customer Empathy, Hardware compatibility, and Analytical tool are the challenges that Financial institutions should figure out for successful implementations. Accuracy and reliability, along with managerial interest, have been identified as new challenges in the adoption of IoT

technology in the financial industry. Ensuring the accuracy of IoT technology is crucial to prevent any incorrect financial activities. Proper training and testing of the technology are essential to achieve high levels of accuracy and reliability in its operations. Besides that, Managerial interest also involves fostering a culture of innovation and openness to change. Embracing new technologies like IoT requires a willingness to challenge traditional approaches and adapt to evolving market dynamics.

Unrealistic expectations and Lack of Customer Empathy were common findings in the literature review and interview results. While these issues may not be directly related to IoT itself, they play a crucial role in influencing its successful implementation. Firstly, Unrealistic expectations among stakeholders and users can lead to misguided perceptions of what IoT can achieve. Secondly, Understanding the needs, concerns, and pain points of customers is essential in tailoring IoT solutions to their specific requirements.

Lastly, Hardware compatibility, Analytical tool, and Data density were not mentioned by interview participants but in the literature review. However during a follow-up question, one of the participants (IP-1) mentioned that *“I get to know that people now align with those IoT devices with cloud servers, where they can store the information on a larger scale, so the information doesn't get crashed down or missing from the server itself. And it is always there for them, so they can utilize the information more clearly for their products or marketing. I guess that's why I know they are aligned with the cloud, so they can have a better result.”* meaning that one of the challenges mentioned in the literature may be solved by now. Besides that integrating IoT technologies into existing equipment, hardware, and legacy machines can be a challenge. IoT devices generate vast amounts of data and storing and securing this data can be both costly and resource-intensive.

The data collected regarding the time frame to overcome obstacles in IoT adoption is a valuable addition to the research. The finding that IoT applications are still evolving and being explored aligns with the dynamic nature of technology. As IoT continues to evolve, innovations, use cases, and solutions are likely to emerge. This ongoing development presents both opportunities and challenges for businesses and organizations looking to adopt IoT technologies.

Considering the expected time frame of 5-10 years for more IoT adoption, it is evident that widespread implementation may take some time. During this period, changes in people's perceptions and openness towards IoT, along with the resolution of related issues, will play a critical role in supporting its integration. Public perception and trust in new technologies are vital factors influencing their adoption rate. Therefore, efforts to educate and raise awareness about the benefits and security measures of IoT applications can help build confidence among users and stakeholders.

The diagram illustrates the categorization of IoT use cases within the Financial industry. It shows the utilization scenarios extracted from interview insights, accompanied by the supporting capabilities facilitating each use case. Besides that, the impact and impact area of each use cases were reflected. In the last column, the value of the use cases is presented.

For example, Anti-money laundering seemed to be one use cases powered by high processing speed and communication and data-sharing feature. It potential can have impact on Financial Institutions by maintaining strong security measures. As a result it can provide value of better financial products and security towards finance.

Moreover, the diagram also takes into account potential challenges, along with the projected timeline to address these issues and embrace the implementation of these use cases.

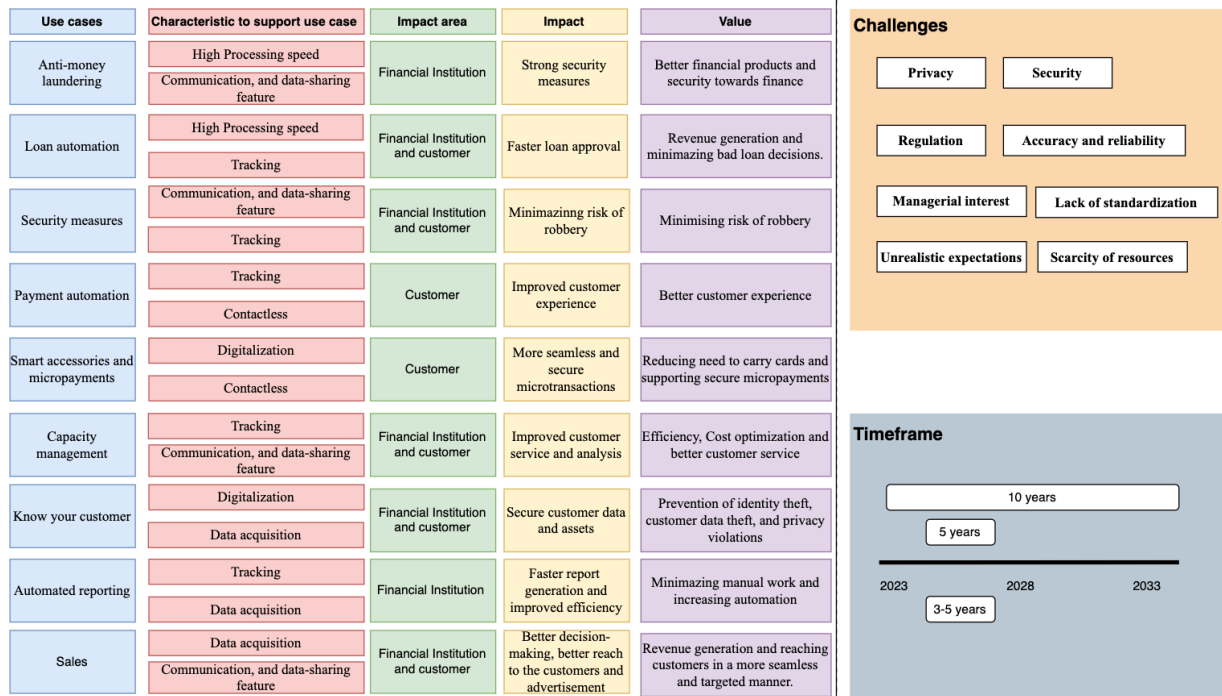


Figure 4: Classification of IoT use cases in Finacial Industry

5. 1 Limitations

This section aims to address the potential limitations that could impact the findings of this research. It is important to acknowledge these limitations to provide a comprehensive understanding of the study's scope and implications.

We employed the semi-structured interview method as the primary approach to collect qualitative data in this study. However, it is important to acknowledge that this method also has its limitations. One limitation of semi-structured interviews is the potential for observer bias. The open-ended nature of the interviews may inadvertently influence respondents towards certain answers or lead them in a particular direction.

Furthermore, it should be noted that during the process of reaching out to potential interviewees, some individuals preferred to provide their answers in written format rather than engaging in face-to-face or verbal interviews. While this approach allowed for flexibility and convenience, it

did present limitations in terms of exploring specific cases or asking follow-up questions in real-time. The written format of the responses may lack the depth and richness that can be captured through direct conversation.

Additionally, another potential limitation can be the sample size and selection of participants. The research may have relied on a limited number of interviews or a specific group of individuals, which might not fully represent the diverse perspectives and experiences within the financial industry. It is crucial to consider the potential biases or limitations in the participant selection process to ensure the generalizability of the findings.

6 Conclusion

The objective of this thesis was to investigate the current state of Internet of Things (IoT) adoption in the financial industry. It sought to explore various potential use cases of IoT technology, their impact, and their value to both financial institutions and customers.

Additionally, the research aimed to identify the existing barriers that hinder the implementation of these IoT use cases in the financial sector. To address the aim we formulated Research Questions.

***RQ1:** What capabilities of IoT technology can enable the use cases in the Financial Industry?*

***RQ2:** What are the potential use cases of IoT in the Financial industry?*

***RQ3:** What are the prerequisites to backup IoT implementation?*

***RQ4:** How IoT devices will impact Financial Industry?*

***RQ5:** How could IoT bring value to financial products and services?*

***RQ6:** What is the estimated time of IoT implementation and what challenges prolong the time?*

To address the research questions, a combination of semi-structured interviews and a literature review was conducted. This approach allowed for gathering comprehensive data regarding the current state of IoT technology in the financial industry and provided insights into the varying perspectives within the field. Through this research, a range of use cases, their associated values, key characteristics, and prerequisites of IoT technology were identified. The impact and potential value of these use cases were analyzed, shedding light on their significance in the financial industry. Additionally, the research aimed to estimate the potential timeline for overcoming the challenges associated with IoT implementation.

Looking ahead, there are opportunities for further development of the framework. As technologies continue to advance rapidly, the list of use cases and the value they bring can be expanded and refined in the future. Furthermore, as more data becomes available, it would be worthwhile to conduct more in-depth research on the future impact of IoT on the financial sector. This would contribute to a more thorough understanding of the subject and facilitate informed decision-making in the industry.

Recommendations for further studies

During the thesis writing process, several recommendations for further studies emerged. One significant improvement is to increase the sample size of the interviews while maintaining a balanced representation of both IoT and Finance experts. A larger and more diverse sample can enhance the research's credibility and provide deeper insights into the perspectives of different stakeholders.

Additionally, it is essential to address the contradictions found in the interview results. Exploring these contradictions in more depth can lead to a better understanding of the underlying factors influencing the participants' viewpoints. Conducting follow-up interviews or surveys may help clarify these discrepancies and identify potential reasons behind them.

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Appendix

I. Research questions:

1. What do you think about the Internet of Things and how would you describe the current state of IoT technologies in the financial industry?
2. What are the expected use cases of IoT in the financial sector?
3. Which characteristics of IoT enable these new possibilities?
4. What are the prerequisites for implementing those use cases?
5. From the point of view of financial institutions, what can be the most valuable usage of IoT?

6. In what ways can the Internet of Things (IoT) transform financial services and organizational processes?
7. How can those modifications affect the way customers engage with financial products or services?
8. Which IoT device is expected to bring the most value to Financial institutions?
9. How big do you expect the value to be for these use cases?
10. How likely will the use case be used in real life?
11. What are the main Challenges of IoT in the Financial sector, and how can they be handled?
12. What is the timeframe for overcoming the obstacles and implementing the use case?

Optional

1. What kind of technological advancements are you most waiting for in IoT?
2. What kind of threats could IoT introduce to the financial industry?
3. What do you think about empowering IoT with blockchain, AI and etc?
4. Is there anything else you would like to mention that we have not discussed?

II. Consent form

Consent to Act as a Participant in a Research Study

Study title: The Internet of Things in the Financial Sector

Researcher: Narmin Ahmadova, Master's Student, University of Tartu

Supervisor: Fredrik Milani, Associate Professor of Information Systems, University of Tartu

Introduction: This is a study conducted by a research group from the University of Tartu (Estonia). This study is a part of a Master's Thesis. The study's objectives are to research how the Internet of Things is described and understood, and how the Internet of Things can be used in the financial sector. The study aims to develop a framework for the Internet of Things in the financial sector. The framework will put into the organized system the notable use cases, capabilities, challenges, and timeframes of the Internet of Things in the financial industry.

During the study, Researcher will conduct an interview with you on the topics mentioned above. Researcher will record the conversation during the study.

Participation requirements: To be eligible to participate, a person should 1) be 18 or older, 2) have work experience in the financial sector and/or expertise in the Internet of Things, 3) be a fluent English speaker.

Expected duration of the study: The study will take about 45 minutes of your time.

Risks and Benefits: The risks associated with this research are no greater than those ordinarily encountered in daily life. There are no direct benefits to participants, but the development of the publicly accessible Internet of Things framework is anticipated.

Privacy and Confidentiality: In order to protect the participants' identities during this study, the research team will follow the following procedure. The original recordings will only be accessible to the Researcher and Supervisor. The audio contained in the recordings will be transcribed, potential identifiers will be removed or aggregated, and the original recordings will be deleted afterwards. Your data and consent form will be kept separate. Your consent form will be stored securely and will not be disclosed to third parties.

By participating, you understand and agree that the data and information gathered during this study may be used by the participating university for publication purposes. However, any identifiable information will not be mentioned in any such publication or dissemination of the research data and/or results. The University of Tartu requires all research records to be maintained for at least five years following the final reporting or publication of a project. Aggregated data will thus be archived by the Researcher for that timespan.

Questions about the Study: If you have any questions, comments, or concerns about the study either before, during, or after participation, please contact the Researcher (ahmadova@ut.ee).

Voluntary Participation: Your participation in this research is voluntary. You may discontinue participation at any time during the research activity.

I am age 18 or older. I have read and understood the information above and I want to participate in this study:

☐ Yes ☐ No

Participant: The above information has been explained to me and all of my current questions have been answered. I understand that I am encouraged to ask questions, voice concerns or complaints about any aspect of this study during its course and that such future questions, concerns, or complaints will be answered either by Researcher, by Supervisor, or by a qualified individual.

Researcher: I certify that I have explained the nature and purpose of this research study to the participant, and I have discussed the potential benefits and possible risks of study participation. Any questions the participant had about this study have been answered, and we will always be available to address future questions, concerns, or complaints as they arise.

Participant_____

Researcher_____

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